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Kenya Coffee Mealy Bug Research

Though much has already been written on the subject of mealy bug, the literature on the problem is somewhat scattered and some of it is inaccessible to the planter. In a comprehensive article by Melville on the subject of the Common Coffee Mealy Bug of Kenya, published elsewhere in this issue, the author has brought together a lot of information from the work of others which appears to him to have a bearing on this difficult problem at the present day, and has added to it the results of the further investigation undertaken during his past year of service in Kenya. Our knowledge of the whole problem has been brought up to date in such a way as to present

a complete picture of it and a clear indication of the direction in which the solution lies.

The motive underlying the information given about the insect in the earlier part of the article is to show the reader what a sound basis there is for attempting to control it through biological means, that is by parasites and predators. Thus correct identification of the insect is of paramount importance, since however similar the different species of mealy bug may seem, the numerous parasites connected with the mealy bug group are able in most cases only to breed on their own particular species within the group. Therefore so long as the Common Coffee Mealy Bug of Kenya was thought to be

Pseudococcus lilacinus the parasites of that species were the ones tried out. That they failed served as additional evidence, if that were needed, that this mealy bug was not *Pseudococcus lilacinus*. We are indebted to Dr. Le Pelley for the discovery of the true identity of the Common Coffee Mealy Bug of Kenya which he has described as *Pseudococcus kenyae*. Now, therefore, a more logical and hopeful search for its specific parasites is possible.

Before, however, any effective control by parasites can be hoped for in the Central Province of Kenya it is necessary to show that specific parasites of this mealy bug are not already present there, in other words, that it is a pest introduced from elsewhere and that it has been introduced without its specific parasites. Melville proceeds to show by a cogent series of facts that demonstrate that this is the case, and there is good reason therefore to hope that the introduction and establishment of its parasites will convert this pest from a major into a minor one. The chances of success are enhanced in view of the conception put forward of ecological islands. These are areas which possess a climate and a set of conditions suitable for the existence of a particular living being—in this case the species of mealy bug known as *Pseudococcus kenyae*. The survey of the factors which control its range in Kenya is therefore of importance, as is the delineation of its actual and possible distribution in the Central Province. It is suggested that a part of the Central Province is an ecological island for this mealy bug and that it is separated from other possible islands of suitability such as areas near Mount Kilimanjaro or a part of Nyanza Province, by impenetrable barriers of mountain ranges or thorn scrub savanna country. Experience elsewhere indicates

that biological control of insects is more effective in ecological islands than in continental areas and, incidentally, the concept of ecological islands for *Pseudococcus kenyae* in East Africa suggests that with adequate precautions this pest may be excluded from those areas in which its development is possible but which it has not yet reached.

Having cleared the ground of the fundamentals necessary to biological control, the article proceeds to deal with various possible methods of control. Spraying the mealy bug or poisoning its attendant ant are shown to give little hope of success, and the banding method of control is for the present still considered the planters' best weapon against this pest. Planters will be aware that tests of banding greases are now continually in progress by the Kenya Coffee Team and they should keep in touch with the results of these as published in the Press.

With regard to more indirect measures of control, Kenya coffee planters will be interested in the sections on the ecology of the mealy bug and the ant in view of the opinions so often expressed that certain areas are more susceptible to outbreaks of mealy bug than others, and that certain areas never suffer from outbreaks, and that if the reason for this was discovered a cure for the pest might be found.

An investigation into this subject was recently carried out by Melville and Gethin Jones. Their survey covered a wide range of local conditions which might have been expected to have an influence on mealy bug outbreaks. It was found, however, that the real local factor of importance in mealy bug outbreaks is the presence of the ant *Pheidole punctulata*.

This ant seems able to produce an outbreak in any situation and thus control

measures based on an alteration of local factors which might influence the mealy bug will be of no avail. Investigations are, however, in progress to see whether it may be possible to influence *Pheidole punctulata* by soil treatments not incompatible with good farming practices in such a way that it cannot become active enough to produce an outbreak.

Finally, the prospects of control by biological means are discussed and it is clear that this method of control is rightly regarded not only as the most promising but also as the most universal and fundamental in its action, being applicable to all kinds of crops throughout the mealy bug range. If successful, this method of control is likely to reduce very materially the cost of coffee growing to planters in the mealy bug areas. The description of the mealy bug as a new species, its introduced status and the concept that the present mealy bug area is a distinct ecological island have all an important bearing on the prospects of the successful biological control of this pest. Everything is dependent, however, on finding the indigenous home of *Pseudococcus kenyae* and the specific parasites which may be controlling it there. In this connexion the occurrence of this mealy bug in Uganda and the Lake area of Tanganyika Territory presents an interesting problem since it is regarded as a minor pest in these areas. The Lake area is a distinct area of distribution, widely separated from the Central Province of Kenya, and since this mealy bug is a minor pest there it may be a part of its indigenous distribution. If this is so then it is possible that parasites may be responsible for its control. A decision as to the status of the mealy bug in Central Africa is thus of primary importance and an investigation is now being carried out in this area in an attempt to elucidate this point. If any useful natural enemies of *Pseudococcus*

kenyae, other than those at present known in Kenya, are discovered, these will be despatched to the Scott Agricultural Laboratories for trial.

The article on mealy bug will have a wider range of appeal than to planters and entomologists. In view of the variety of crops seriously attacked by this pest—especially food crops—this subject must be of interest and concern to those responsible for native administration and agriculture alike, both in Kenya and Tanganyika Territory. With food crops, biological control is probably essential and successful work in this respect will both ensure certain foods to the diet of natives in parts of the Central Province of Kenya and minimize fear of losses of coffee and of food crops in Tanganyika Territory from this pest. G. J. L. B.

Sisal Waste and its Uses

In parts of Europe, we learn, the stubble shaved off men's chins each morning is now being collected and made into velour hats. Such serves to illustrate that new uses are constantly being found for waste products and there seems to be no reason to despair of finding some solution to the waste problem on sisal estates.

Resulting from an invitation for notes or articles on the composting of sisal waste, given in these columns last July, the Editor has received an interesting contribution from the Dutch East Indies on the subject of the utilization of sisal waste. The first part of the article appears in this issue and describes the various systems tried in Java for dealing with the waste effluent from a sisal factory and gives details of its value as a fuel or a fertilizer. Others have examined its uses for the manufacture of paper, alcohol, or producer gas for engines, but so far there has been little development in these directions. In East Africa most attention

has been paid to the recovery of flume tow.

Originally sisal producers in Java endeavoured to make use of the waste as fuel. There are also a few estates in East Africa employing sisal waste as fuel; the majority, however, ceased to use steam power over a decade ago and nowadays depend upon Diesel engines or electricity. Others, more fortunately placed, have been able to harness water power on the estate. Consequently, after passing through an evolutionary period as regards providing a power supply for their factories, it is unlikely that sisal estates in East Africa will ever return to steam except in the event of artificial dryers becoming general. In that case, of course, the waste could be used for heating purposes. Obviously the more self-contained a sisal estate can be the better.

Whilst not all the manurial value of sisal waste is lost if it is burnt as fuel, it seems to be clear that the best part fitted for it in the economy of a sisal estate is as an organic manure. Sisal production is predominantly an extractive business in more ways than one, and in so far as the soil is concerned it is widely recognized that such a process cannot be continued indefinitely. The plant food ingredients of sisal waste are by no means unimportant and warrant preparing the waste in a suitable form for applying to the land. Such steps would help to change the present cultural methods from "planting" to "farming" and thereby lend some permanence to the productivity of an estate. One system of composting the waste has already been described in this journal. Estates which have not tipped their fertility into a river or the sea may find composted material in their waste dumps if these are of fairly long standing, and what was once regarded as a handicap may eventually prove to be a blessing in disguise.

Apparently four-fifths of the total plant food constituents in sisal waste are carried away in the waste water, and in Java this is used by peasant cultivators at lower elevations. Owing to topography or the existing location of the factory, it is doubtful whether many estates in this country could direct the waste water to irrigating and fertilizing sisal fields, although on some properties it could be diverted to orchard or food crops. In this connexion it is necessary to note that in the Dutch East Indies about five tons of washing water are used per ton of leaf decorticated as compared with three or four tons in East Africa. The more water that can be used the less chance is there of the waste water becoming overloaded with fresh fermentable material and putrefying conditions being set up.

In addition the article throws some light upon the standards of sisal cultivation in Java and Sumatra which cannot fail to interest sisal growers in this country.

G. W. L.

Note re Binding of Volumes

Several subscribers have written asking whether any arrangements have been made for binding past numbers of the *Journal*. The possibilities of doing so, at a rate likely to be acceptable to subscribers, are being investigated. A main difficulty at present is that no idea can be formed of the number of binding covers that might be required annually. If those subscribers who are interested would send a post card to the Government Printer, P.O. Box 128, Nairobi, stating how many binding covers they will require, i.e. Volumes 1, 2, 3, it would facilitate further efforts to arrange binding. Volumes must not be sent to the Government Printer, Nairobi, for binding.

Kenya Coffee Mealy Bug Research

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Kenya Colony.

INTRODUCTION

The Common Coffee Mealy Bug (*Pseudococcus kenyae* Le Pelley) is still a major burden on the coffee industry of the Central Province of Kenya on account of the loss of crop that it occasions and the cost of control measures. It has, with one or two exceptions, penetrated wherever coffee is grown in the Central Province, and it is expected that it will eventually reach some of those areas not yet affected. It is also a severe pest of native crops in the area referred to above. Yams, pigeon peas, cotton, sweet potatoes and beans are the principal crops attacked. The cultivation of yams has ceased in some parts of the reserves on account of the attack of this mealy bug and the same insect ranks as one of the worst pests of cotton, a new crop in this area. The mealy bug has been gradually spreading through the native reserves and a considerable area is now affected. There is a further large area of the reserve into which its ultimate spread is extremely likely.

Wherever the mealy bug has been present for a number of years, as in the coffee-growing areas, the damage it causes, though severe, is not likely to increase beyond that experienced at present, but will vary from year to year, depending on the interaction of the various factors of the mealy bug complex (coffee, mealy bug, ants, natural enemies of mealy bug and the parasites and predators of these natural enemies) under varying climatic conditions. In areas very recently infected this state of equilibrium has not yet been reached and outbreaks in such

areas are often unusually severe, probably because local natural enemies have not yet adjusted themselves to the presence of the mealy bug, and the balance is strongly in its favour. This state of affairs is only temporary and conditions in the newly infected areas are soon the same as those in the older infected areas. As this mealy bug has not yet reached its limits in the Central Province, its further spread must result in an increase in the total economic damage caused.

It is intended in this article to bring together such knowledge of the mealy bug problem as has been accumulated by various workers, to view this in the light of recent work and to indicate the present trend of research into the control of this important pest.

PSEUDOCOCCUS KENYAE LE PELLEY— A NEW SPECIES

At the date of the original serious outbreak the Common Coffee Mealy Bug was thought to be *Pseudococcus citri* (Risso) but was later identified as *Pseudococcus lilacinus* Ckll. and it went under that name until the year 1935 when Le Pelley [2] described it as *Pseudococcus kenyae*. The Kenya mealy bug has been shown to be distinct from *P. lilacinus* in certain morphological characters. It is understood that Dr. Le Pelley will publish, at a later date, comparative observations on the external features and biological characters of these two species. It is sufficient to mention at present that living specimens of *P. lilacinus* (obtained from South India) and *P. kenyae* reared together in quarantine at the Scott Agricultural Laboratories were readily distinguishable

(Figs. 1 and 2) and further that none of the internal parasites of *P. lilacinus* recently imported from the orient would attack *P. kenyae*.

P. kenyae is a relatively flat insect, having a well-marked groove and transverse grooves on the dorsal surface. The relative breadth of the transverse wax bands and the length of the radial wax filaments are also characteristic of this species. (See Fig. 1.)

Compared with *P. kenyae*, *P. lilacinus* is a convex insect. The central groove is inconspicuous. Transverse grooves can be seen but the wax conformation is quite distinct from *P. kenyae*, the radial filaments being also much shorter. (See Fig. 2.)

The recognition of the Common Coffee Mealy Bug as a new species is an extremely important advance. When biological control work is contemplated, the correct identity of the host insect is of paramount importance and this is especially true in the case of mealybugs, the parasites of which are noted for their specificity. In the past much confusion has resulted from the fact that the Kenya mealy bug went under the name of *P. lilacinus*. *P. lilacinus* is an oriental species and now that *P. kenyae* is known to be distinct from it, *P. lilacinus* can be forgotten as far as the Kenya Coffee Mealy Bug problem is concerned.

P. KENYAE—AN INTRODUCED PEST IN THE CENTRAL PROVINCE OF KENYA

A decision whether the Common Coffee Mealy Bug is an indigenous or an introduced insect in the Central Province of Kenya is of great importance when biological control is contemplated. The chances of success with this type of control are enhanced in the case of an insect introduced without its natural enemies because, once the natural home

of the insect has been discovered, it may be possible to import its natural enemies.

James [1] puts forward conclusive arguments to show that the Common Coffee Mealy Bug is introduced and they have recently been further substantiated. In the following sections the reasons for looking upon *P. kenyae* as an introduced pest are considered.

(I) Original outbreak and subsequent spread.

Prior to 1923, the date of the first serious outbreak, a mealy bug was known on coffee in Kenya. This insect was identified in 1909 and 1911 as *Pseudococcus citri* (Risso). It was recognized as a minor pest. In 1923 coffee mealy bug suddenly became epidemic on coffee in the Ruiru-Thika area and caused much damage. It was soon realized that the mealy bug appearing in outbreak form was not *P. citri*. It was then identified as *P. lilacinus* and recently described as a new species, *P. kenyae*.

The years that followed 1923 were characterized by a gradual spread of this mealy bug both on coffee and on native crops into areas not previously occupied by it. As an example of the rate of its spread it may be mentioned that it was first noticed in Donyo Sabuk coffee in 1927, that is four years after its appearance in the Ruiru-Thika area, the distance covered being about forty miles. Again, the writer recently carried out a survey of mealybug infestations in the Fort Hall, Nyeri, Embu and Meru native reserves of the Central Province, where several crops are being seriously attacked. In this survey the margin of the present zone of distribution of *P. kenyae* was found. In such a position mealy bug was a new "disease" to the natives, and the concensus of opinion of many of those questioned in different parts of

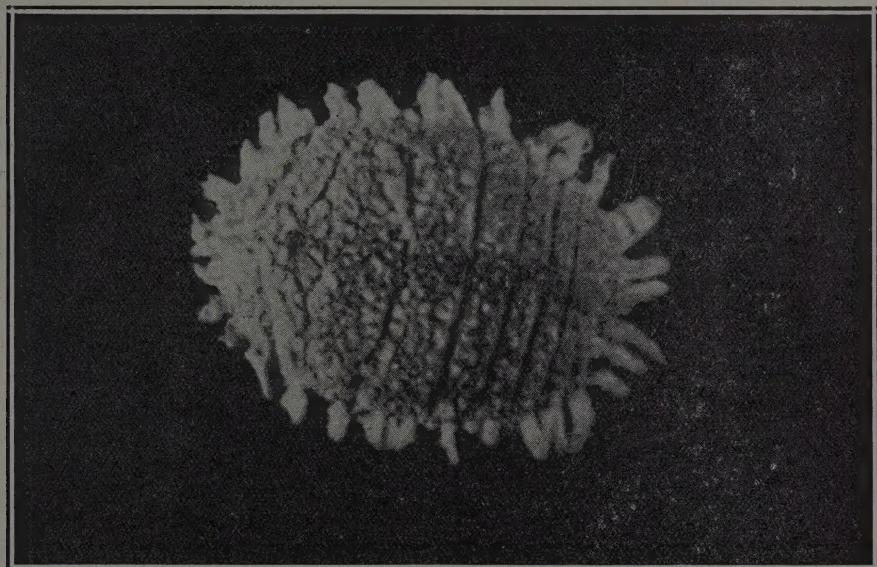


FIG. 1—*Pseudococcus kenyaensis* Le Pelley.
From Coffee, Central Province, Kenya.

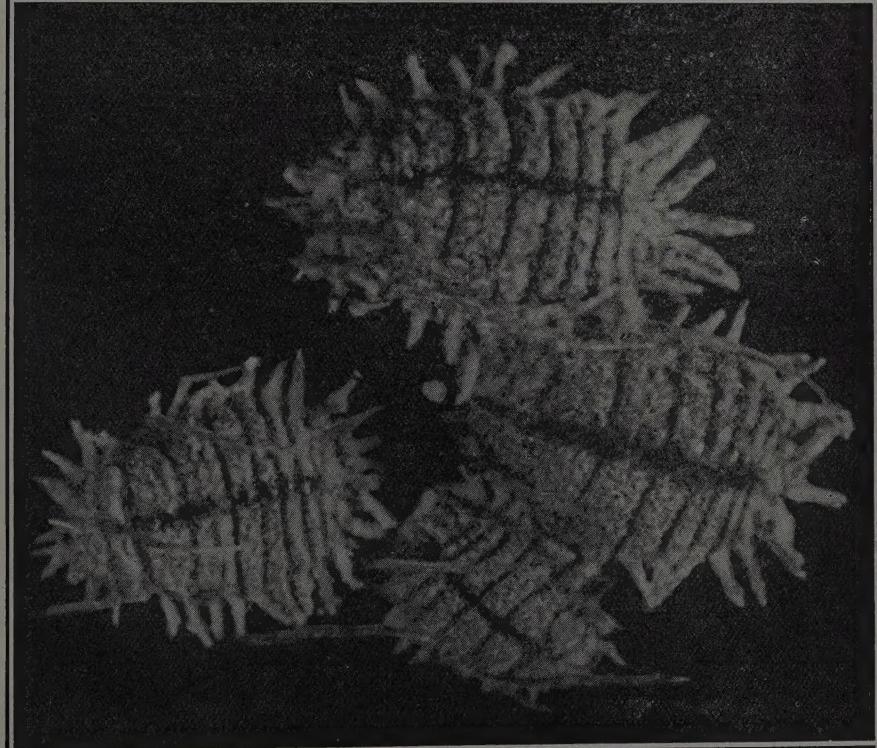


FIG. 2—*Pseudococcus lilacinus* Ckll.
From South India.

these reserves was that the mealy bug was an insect which was gradually spreading from the Nairobi-Thika area. Going beyond the present marginal zone of distribution of *P. kenyae*, areas were found which are obviously suited to the development of mealy bug in that the attendant ant *Pheidole punctulata* Mayr. is already present and climatic conditions are also suitable. These considerations alone, even if no further evidence were available, are sufficient to show the introduced status of *P. kenyae*.

It should be remembered that *P. citri* is still present in the Central Province but that its presence tends to be masked by the much more abundant *P. kenyae*. The incidence of *P. citri* has probably also been much reduced by the greasebanding of coffee trees to control *P. kenyae*. The relatively efficient natural control of *P. citri*, assisted by greasebanding, would have this effect. In areas not yet infected by *P. kenyae*, *P. citri* can still appear in small outbreaks, attended by *Ph. punctulata*. This was probably the position before 1923 in the whole coffee area of the Central Province and the status of *P. citri* even to-day is that of a minor pest.

(2) *Pheidole punctulata* Mayr.

The appearance of the ant *Pheidole punctulata* may be argued as being the cause of the sudden outbreaks of mealy bug in 1923 and subsequent years. James [1] on this subject remarks as follows:—

"*Ph. punctulata*, however, was collected at many points near Nairobi and Thika in 1914, by the Alluard and Jeannel Expedition, and there is no doubt that this species of ant was present in the Nairobi-Fort Hall area long before coffee plantations existed in it.

Moreover, as a matter of personal observation, in certain districts where *P. lilacinus* is only of recent occur-

rence, *Ph. punctulata* was identified in them two years before infestations of *P. lilacinus* occurred."

The writer has also collected *Ph. punctulata* in the Central Province of Kenya at points where *P. kenyae* has not yet penetrated. The same species of ant has also been collected in Kenya at the coast and at many points in the Northern Province of Tanganyika Territory. James recorded this ant in the Lake area of Tanganyika and in Uganda and Wheeler [5] gives ten records of its occurrence in the Belgian Congo.

It is thus certain that *Ph. punctulata* was present before the mealy bug and it would appear that this ant has been widely established in East Africa for some considerable time and is probably indigenous.

In view of these facts the only tenable explanation of the sudden mealy bug outbreaks is the introduction of a new mealy bug.

(3) A study of internal parasites.

Mealy bugs as a group are extremely susceptible to the attack of parasites and predators. They are poorly protected from these enemies, being soft-bodied, relatively immobile and, except a few, fully exposed throughout life. A study of the internal parasites of mealy bugs is particularly informative on the question of the status of these insects, for in a mealy bug in its natural home one expects to find a fairly high percentage of individuals attacked by internal parasites, some of which may be specific, i.e. having that mealy bug as their only host. Conversely, if a mealy bug is found to be practically free from internal parasites it can be argued that it is an introduced insect.

P. kenyae is estimated to be attacked by internal parasites to an extent never

exceeding one per cent. The parasites so far obtained comprise four or five species of primary parasites and two species of hyperparasites. It would appear that the primary parasites are only rarely able to develop in *P. kenyae* and with some of the species it has been shown they are important parasites of other mealy bugs. With further work, it is probable that all the primary parasites bred from *P. kenyae* will be found to be important parasites in some other hosts.

P. kenyae can thus be looked upon as an introduced insect which has been open to the attack of parasites of other mealy bugs and related insects already present in the country. These parasites have been unable to attack the new species to any appreciable extent because each one is highly adapted to its own particular host or hosts. The few that do breed in *P. kenyae* are enabled to do so because its resistance to them is not sufficiently great to confer complete immunity.

Hyperparasites are not so specific as primary parasites and attack a much wider range of hosts. Accordingly, their study does not help to establish the status of a mealy bug.

(4) A study of predators.

A study of the predators of *P. kenyae* is not likely to produce such valuable evidence as a study of the internal parasites, because the predators usually have a range of host insects. A considerable amount of work has been done on the predators of *P. kenyae*. The present greasebanding control measure is dependent on the activities of these predators and on occasion they do very useful work. There is however a certain amount of evidence to show that *P. kenyae* comes fairly low in the preference list of some of these predators. If certain other insects are available they will not feed upon *P. kenyae*. This has been noticed particu-

larly in the ladybird, *Chilocorus angolensis* Crotch, an important mealy bug predator, which seems to prefer Green Scale, *Coccus africanus* (Newst). This may explain the lag which occurs frequently before predators appear to clear up an infestation after greasebanding has been adopted and may also explain the complete disappearance of predators liberated on mealy bug infested coffee, the attraction of the mealy bug for the indigenous predators not being strong enough.

This behaviour of predators is further evidence supporting the view that *P. kenyae* is an introduced insect.

(5) A comparison of the Central Province of Kenya with the Northern Province of Tanganyika Territory.

There are two separated areas to the south of Mount Kilimanjaro and Mount Meru respectively, similar in vegetation, fauna and climate to a large area in the Central Province of Kenya.

With regard to mealy bugs found on coffee, there are five species common to all these areas whilst in the Kenya area a sixth occurs, namely, *P. kenyae*. When the essential similarity of these areas is borne in mind this fact would again seem to support the view that *P. kenyae* is an introduced insect in Kenya.

(6) Conclusion.

When the foregoing evidence is considered there seems no doubt that *P. kenyae* was introduced to the Central Province of Kenya. Once there its spread was typical of an introduced insect. An association was formed between this mealy bug and the ant *Ph. punctulata* which was already present in the area. Completely lacking in specific parasites and predators, *P. kenyae* provided excellent material for the ant to work on and resulted in this particular mealy bug becoming a major pest.

FACTORS CONTROLLING THE RANGE OF P. KENYAE

(1) Altitude and *P. kenyae*.

The coffee mealy bug appears to have reached its upper altitude limit at certain points of its present range. In the Limuru district, 6,500 feet can be taken as the upper limit. It is considered that this limit will be somewhat lower in the more humid areas nearer Mount Kenya.

As regards the lower altitude limit little definite information has been available until recently. The previous lowest record on coffee was in the Makuyu District (4,500 feet) and though it was known to exist in the native reserves the area which it occupied or the lowest altitude at which it existed were not known. The lowest record of *P. kenyae* found during a recent survey by the writer was at 3,800 feet on the Sagana River near Fort Hall. In the native reserves of the Central Province there are areas under host crops which are much lower than this but no *P. kenyae* was found in such of these as were visited. The reason for this is not likely to be that the mealy bug will not develop at these altitudes but merely that it has not yet penetrated thus far and the indications are that it will eventually do so. The infestations at 3,800 feet were very severe and there is no appearance of the bug's activity falling off as the altitude becomes lower.

The rate of development of the mealy bug will naturally depend on the climate. At the upper limit of its range, for instance, the development is slower consequent upon much lower temperatures. In these conditions *P. kenyae* has been noticed to produce a prominent ovisac, an abnormal feature indicative of slower development.

(2) Altitude and the ant.

The ant *Pheidole punctulata* is widely distributed in East Africa but it is neces-

sary to consider its altitude range as well as that of *P. kenyae*, because the pest status of mealy bug depends on the presence of *Ph. punctulata*. In East Africa this species of ant has been found from sea-level to 6,500 feet, its approximate upper limit in the districts of Upper Kiambu and Limuru. In areas nearer Mount Kenya this limit is expected to be somewhat lower. It is important to realize that the nearer one comes to the upper altitude limit the less easily is *Ph. punctulata* found and the more localised are its occurrences. Consequently outbreaks of mealy bug are not common at these altitudes and those that occur are less serious than they would be lower down owing to the effect of cold on both the ant and the mealy bug. The ant appears to be very active throughout the remainder of its altitude range.

THE DISTRIBUTION OF *P. KENYAE* IN THE CENTRAL PROVINCE OF KENYA

The area in which *P. kenyae* is already known to be present is as follows:—

On coffee in the alienated areas of Limuru, Upper Kiambu, Lower Kiambu, Ruiru, Thika, Makuyu, Donyo Sabuk, Machakos, Nyeri and Ngong.

On native crops in the reserve districts of Kiambu, Thika, Fort Hall (except at low altitudes), Nyeri (probably continuous from Sagana to Nyeri, but this is not certain), Embu (mealy bug has apparently only arrived recently and has not yet reached its limits).

In the Machakos district *P. kenyae* is already present in the higher coffee farms but it has not yet reached the lower ones. It is obvious that it is likely to spread to the Meru district, and it seems reasonable to assume that it will ultimately spread to the Tana River area. Its spread towards the Coast, however, will almost certainly be checked by the thorn scrub savannah country to the east, and this

type of country will also check its spread in other directions.

Since thorn scrub savannah country owing to its dryness and the absence of suitable host plants seems to form an impenetrable barrier to the spread of *P. kenyae*, and since the insect cannot thrive much above 6,500 feet, it is clear that areas suited to it, but surrounded by such barriers, may be regarded as ecological units or "islands". Parts of the Central Province of Kenya form one such island, there is a separate small island in the Machakos district, one south of Mount Kilimanjaro and one south of Mount Meru. These islands are all separated by barriers, mostly of the thorn scrub savannah type, and only the two in Kenya are as yet infected. Other such islands may yet be discovered in East Africa.

The existence of this mealy bug in ecological islands may well have a bearing on biological control of the pest. Outstandingly successful cases of such control in continental areas have only occurred in ecological islands within the continents. In California, for example, notable successes have been achieved in areas separated from the rest of the United States of America by great barriers of deserts and mountains.

INVESTIGATIONS INTO MEALY BUG CONTROL

(1) Banding.

The use of banding grease as a deterrent against the ant *Pheidole punctulata* is well known to coffee planters of the Central Province and is of great value in the control of mealy bug on coffee when properly carried out. It is important that it should be applied at the earliest possible moment after mealy bug is discovered, and banding on the first indication of the attendance of *Ph. punctulata*, even though mealy bug cannot be found in the trees, is a sound practice. In areas where

banding has to be continuous it is essential that it be made completely effective as soon as mealy bug or attending ants are discovered. There is good reason to believe that early attendance of the ants has a great influence on the production of an outbreak. If undisturbed in the early stages, the ants seem to give the mealy bug infestation an "initial push" which it may be extremely difficult to counteract. If the banding control is not adopted or if it is inefficiently carried out mealy bug will spread rapidly and lead to a situation which it is not easy to rectify.

After the banding operation is completed, reliance is placed on certain indigenous predators to control the mealy bug. Frequently these predators do very good work but there are occasions when they fail completely. For example in the latter months of 1936 and the early months of 1937, observation by the writer showed that the indigenous predators had failed on account of an abnormal increase in the parasites of certain of these predators. Many extremely serious outbreaks occurred at this time in spite of banding and the position did not improve until the onset of the long rains in March at which time the percentage of parasitism of the predators suddenly dropped and they were thus enabled to multiply and effect a control.

Again there is frequently a long interval between the application of banding grease and the appearance of predators. This is due in all probability to the fact that the mealy bug is not a strong enough attraction for the indigenous predators in the presence of other preferred hosts.

Greasebanding is, however, an expensive control, especially in areas where continual banding is necessary to ensure freedom from mealy bug. The difficulties of keeping bands effective are well known, and this adds considerably to the

expense of this control measure. In view of the expense of banding and of the damage that this mealy bug sometimes causes even when banding is efficiently carried out it has been obvious for some time that better control is urgently required in the coffee areas.

The control of mealy bug on native crops is also difficult. Control by grease-banding is obviously out of the question. The best procedure to adopt for the present would seem to be to impress upon the natives the importance of cutting out and burning plants or parts of plants as soon as they become infested. The difficulty of getting natives to do this is realized, but it is considered that this procedure, coupled with the growing of crops for as short a term as is practicable, is the best method of preventing an infestation that will attack and ruin nearly every crop. When mealy bug does become rife in this manner, there is little that can be done save wait until the infestation comes to the end of its cycle. Thus in the native reserves also the need for further control of this pest is very apparent.

(2) Direct attack on the mealy bug and the ant.

The question of a spray for use against mealy bug has been worked on thoroughly in the past by members of the Kenya Department of Agriculture. Although certain sprays can on occasion be useful against mealy bug their application is very limited and no really effective economical mealy bug spray has been developed. Those which can on occasion be used have to be applied perhaps two or three times before control is effected. Although this may be justifiable in a small localised outbreak, the expense involved in carrying it out in a large area would be quite prohibitive. It must also be borne in mind that to warrant the use of a spray

on a large scale it would have to be effective enough to be capable of superseding the banding control completely.

It would appear therefore that the spray method cannot be considered to hold much promise.

Direct attack on the ant *Ph. punctulata* has also been much experimented with in the past. Innumerable tests have been made with poison baits but *Ph. punctulata* has been found to possess a high degree of "intelligence", and although the baits are visited to begin with the ants quickly learn their nature and the visits cease. The Argentine ant poison which has been used effectively against *Iridomyrmex humilis* Mayr. in the United States of America has recently been experimented with, but *Ph. punctulata* after feeding vigorously on this poison for about half an hour subsequently avoided it entirely. The Argentine ant commonly invades houses and feeds on various foodstuffs. It is consequently a much easier ant to attract with baits than is *Ph. punctulata*.

Other methods of direct attack on the ant, such as spraying and soil fumigation, are rendered futile on account of the depth of the nests, particularly during the rains, by the large number of the nests and by the extensive area which would require to be treated by a method certain to be expensive.

In general there is no hope of successful control by a direct attack on *Ph. punctulata*.

(3) Ecological studies on *P. kenyae*.

Notley [4] puts forward the suggestion that it might be possible to combat mealy bug by altering the ecoclimate of the coffee plantation. If high effective temperatures are responsible for outbreaks of mealy bug, reduction of these temperatures, for example by shade, might result in a reduction of the incidence of mealy

bug and moreover one would expect to find mealy bug outbreaks in situations which tend to give higher temperatures. It has been shown by Notley [3] that in the Coffee Thrips (*Diarthrothrips coffeae* Williams) outbreaks can be correlated with local factors which favour an increase of temperature, e.g. on leeward slopes, behind windbreaks and on poor soils.

Several planters have reported that mealy bug outbreaks have a tendency to recur in areas where they have been known before and it has been possible recently to carry out a survey of mealy bug outbreaks in Kiambu and Limuru districts with a view to determining whether any local factor could be held responsible. These higher areas were deliberately chosen because it was felt that local factors producing temperature differences would be more apparent there than lower down and that consequently any influence that these factors might have on mealy bug outbreaks would be more clearly demonstrated. This survey was carried out in conjunction with the Soil Chemist of the Coffee Team, and a large number of farms were visited.

It was found to be impossible to correlate mealy bug outbreaks with any known local factors whatsoever. Outbreaks were encountered in a variety of positions, such as on top of ridges, on various exposures, in sheltered places, with various soil conditions, and in shaded and unshaded coffee. At these higher altitudes the presence of the mealy bug without the ant *Ph. punctulata* does not lead to a serious outbreak, even in areas where temperatures are higher owing to the influence of local factors. This does not deny that an increase of temperature increases the rate at which the bug develops, which is undoubtedly true. But when two species of insect are necessary

to produce an outbreak the local conditions influencing both must be considered. It is possible to imagine a set of conditions in the coffee trees favourable to the mealy bug and another set of conditions in the soil favourable to the ants. Where these overlap it may be that a serious outbreak can be expected. Theoretically it would appear that near the limit of mealy bug and ant, outbreaks can only be expected at points where the two sets of conditions overlap, but in practice in the greater part of these high coffee areas the ant, if present, seems capable of overcoming any local disadvantages which the area may possess for the mealy bug and of producing an outbreak. If it had been possible to correlate mealy bug outbreaks with local factors then it would have been possible to attempt to alter these factors and thus effect a control. For example, if outbreaks could have been traced to local temperature conditions, shade might have been employed as a control; but in the course of the survey referred to above outbreaks were found both in shaded and unshaded coffee and they depended only on the presence of *Ph. punctulata*.

If the chances of combating mealy bug in these high areas by altering its environment are small, they are much smaller in the lower areas where *P. kenyae* develops much more rapidly owing to higher temperatures and to more vigorous attendance by *Ph. punctulata*.

In short, it would appear that the ant *Ph. punctulata* is the determining factor in an outbreak of mealy bug in coffee in the Central Province of Kenya. There are a few recorded severe outbreaks of mealy bug without *Ph. punctulata* but these have all occurred in a hot low-lying area. Further reference will be made to the importance of *Ph. punctulata* in the next section.

The explanation of such recurrent outbreaks as occur is frequently that the mealy bug remains in the area in small quantity even after banding has been employed and the outbreak has "cleaned up". An important part of the control measures against mealy bug is the cleaning of the trunks of the trees below the bands after an outbreak has been controlled above the bands. Mealy bug attended by ants may exist for a long time in the crevices of the bark. It is thus present in the area and ready to initiate a fresh outbreak when suitable conditions arise. On this account the treatment of the trunks with limewash or some other insecticide after an outbreak has been controlled cannot be too strongly recommended.

(4) Ecological studies of the ant.

It has been seen in the previous section that there does not appear to be any possibility of combating mealy bug by altering the ecological conditions as regards the mealy bug itself. The importance of the ant in causing outbreaks has been referred to. More knowledge is required about the ecology of *Ph. punctulata*. On certain farms in various parts of the mealy bug area there seem to be areas which have never had a bad outbreak of mealy bug. If mealy bug has occurred in them it has never become really serious. The explanation may be that the infections which have occurred have taken place when general climatic conditions were not favourable to an outbreak or when the coffee was not in a condition to support an outbreak, but in some cases at least, neither of these explanations covers the facts. The indications are that there is some factor or factors in the soil which prevent *Ph. punctulata* from becoming a dominant species and hence outbreaks of mealy bug do not occur.

A preliminary experiment is at present being laid down on the Karimani Experimental Station, Thika, in order to obtain information on ant ecology and to investigate the possibilities of altering soil conditions (in a manner compatible with good farming) with a view to influencing the development of *Ph. punctulata*. It is proposed to study the effect of practices such as mulching, green manuring, heavy manuring with *boma* manure, etc., on the temperature, moisture content and organic matter content of the soil and to see whether differences in any of these factors have any influence on the mealy bug ant.

(5) Biological control.

The most promising line of research is undoubtedly biological control. Moreover it is a method which, if successful, will control the mealy bug throughout its range whether is be on European coffee or native crops. *P. kenyae* has been shown to be an introduced pest lacking in specific natural enemies. Biological control aims at altering the balance, at present greatly in favour of the mealy bug, to such an extent that no economic damage is caused.

The marked specificity of mealy bug parasites has already been referred to, and although no opportunity of testing parasites of related mealy bugs from other parts of the world on *P. kenyae* will be missed, it is considered that the surest way to success is to make every effort to discover the natural home of *P. kenyae* in order that its specific parasites may be imported. Now that *P. kenyae* is known to be a distinct species there is more hope that this will be accomplished.

P. kenyae has been found in Uganda (Notley [4]) and at Bukoba in Tanganyika Territory (Ritchie *in litt.*, 1936), but has not yet been recorded from any other part of the world. Notley states that it is a minor pest in Uganda, where it is widely

distributed. Ritchie has reported that at Bukoba it is present throughout a large area and that its status there is also that of a minor pest.

The Common Coffee Mealy Bug is thus known to be present in a large area in the vicinity of Lake Victoria. This area is completely distinct from the mealy bug area in the Central Province of Kenya. The first question to be determined is that of its status, whether introduced or indigenous, in this Lake area. If it can be proved to be indigenous then it is expected that it will be found throughout a wide area in Central Africa, existing as a minor pest in a state of balance with its natural enemies under a wide range of climatic conditions, including those similar to the mealy bug area of Kenya. The introduction into Kenya of its natural enemies from such similar areas is most likely to result in a successful control of mealy bug and with this end in view the whole question of the distribution and status of *P. kenyae* in Central Africa urgently requires cleaning up.

The writer hopes shortly to carry out a survey of *P. kenyae* in Uganda, Tanganyika Territory and the Belgian Congo in order to determine whether this mealy bug is indigenous in any part of its Central African range. At the same time the possibility of *P. kenyae* being indigenous in some other part of the world must not be overlooked.

Notley [4] has put forward the hypothesis that the reason for the minor pest status of *P. kenyae* in Uganda is that it is existing in an unfavourable climate. This may well be true as far as parts of Uganda are concerned but if the mealy bug is indigenous in Central Africa then its range is expected to be considerable and climatic conditions in some part of its range are almost certain to approach those of the mealy bug area in Kenya and the unfavourable climate hypothesis

would not then apply. In an area climatically similar the mealy bug would be expected to develop as in Kenya, and if it did not, then natural enemies might be keeping it in check.

The fact that the mealy bug area in the Central Province of Kenya represents a distinct ecological island is favourable to a campaign of biological control in a continental area. This method of control has had the majority of its successes in geographical islands and in continental areas success is more likely to be met with if the pest to be controlled exists in a well defined ecological island within them rather than distributed widely over them.

In the meantime information on other mealy bugs of the Central Province of Kenya and their parasites and predators is being accumulated. Such information is certain to be of value when further parasites and predators are introduced.

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SUMMARY

Pseudococcus kenyae, a serious pest of coffee and native crops in the Central Province of Kenya, is an insect introduced into this area without specific natural enemies. This fact, together with the close association of this mealy bug with the attendant ant *Pheidole punctulata* and the existence of suitable climatic conditions in Kenya, is a satisfactory explanation of the pest status of *P. kenyae*. The mealy bug has not yet reached the limits of its spread in the Central Province, but when it does it will be confined to an area completely surrounded by either dry thorn scrub savannah country or by high mountains.

Control is considered under various headings. Banding is still regarded as a fairly effective though expensive method. Direct attack on the mealy bug or the ant does not hold out much promise as a method of control. A recent survey carried out to determine whether any local factor could be responsible for mealybug outbreaks has shown that the presence of the ant *Pheidole punctulata* is critical. Studies are to be undertaken with a view to determining whether it is possible, by

altering the environmental conditions of this insect by soil cultivation methods, to reduce its activity and thus prevent outbreaks.

The most promising line of research is the introduction of specific natural enemies of *P. kenyae*. The natural home of the mealy bug is not at present known but its discovery is of first importance for there is a strong possibility that specific natural enemies will be found there. Parts of Central Africa are tentatively put forward as likely localities in which *P. kenyae* may be indigenous. Investigations are to be carried out in this area.

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A Pocket Surveying Instrument

The purpose of this note is to draw attention to a little instrument which I have found most useful in agricultural field work. It is called "Philips Pocket Surveyor" and is manufactured by George Philip and Son, Ltd., 32 Fleet Street, London, E.C. 4. The price is only Sh. 2/6 in England. Essentially the instrument consists of two metal arms, one vertical, and one horizontal which rotates upon it through a circle calibrated at every 45 degrees. The horizontal arm has sights for the eye to look along. The vertical arm terminates in a screw which can be screwed into any convenient stick.

The instrument can be used in two ways. When screwed into a stick and thus

supported in a horizontal position, it can be used for laying out right angles quickly and easily. When held loose and swung from a loop at the top, it can be used as a simple level or a sort of clinometer; amongst other things, this enables one to determine the heights of objects, gradients of roads, and to lay out contours. The value of this last use in anti-erosion work need not be emphasized. There are also other uses, all of which are explained in a simple booklet, by which the instrument can easily be mastered by any European or an educated African.

The same firm advertise a Handy Theodolite at Sh. 17/6 net.

G. B. M.

The Utilization of Sisal Waste in Java and Sumatra

By J. E. A. DEN DOOP, *Bandoeng, Java.*

On page 5 of the July 1937 issue of this Journal the editor asks for articles on one's experiences in composting of sisal waste. Although the author's experiences in sisal waste utilization are not just parallel with same of Mr. Layzell, it might be of interest to some readers of this Journal to communicate them here, especially as they comprise practically the whole history of sisal waste utilization in the Dutch East Indies, i.e. in Java and Sumatra.

The author came first in touch with the sisal industry in 1918 as an agricultural research worker in the then largest sisal estate of the Dutch East Indies and as far as he is aware of the whole world, with a factory output of some 6,000 tons of fibre per year. It was an East Java estate. Its factory has since that time already been closed down and many other estates have reached afterwards a much higher production, in Sumatra even, factory outputs of something like 20,000 tons per year.

To understand the development of sisal waste utilization in the Dutch East Indies one must bear in mind that there all sisal factories have sufficient water at their disposal to wash the fibre quite clean in the process of decortication, as a rule some five tons of water being used in milling one ton of leaf, which is, I understand, much more than usually is available for the sisal factories in East Africa. Together with said volume of water which is enlarged somewhat by additional centrifugal and factory washing water, the waste falls into a flume by which it is conducted to the outside of the factory. So far things are the same, I believe, in all sisal factories of Java and Sumatra.

To prevent misunderstandings, which easily could arise from differences in nomenclature, let it be at once decided how the various components of the waste may be named. The waste then may be called everything running in the flume as leaving the factory, i.e. all the leaf material separated in the decortication process from the "fibre" together with about five times as much additional water. "Fibre" is called in this article the ordinary fibre obtained in the decortication process and thus including the ordinary tow but not including the "waste tow". The various components of the waste may be distinguished as follows—(1) the "waste fibre", i.e. the fibre which in the decortication process is lost into the waste through various causes, but by special processes can be recovered from the waste as "waste tow"; (2) the "adherent tissue", i.e. the particles adhering more or less strongly to the "waste fibre", together with those very short fibres which in the process of "waste tow" recovery are lost and join the tissue which is detached from the "waste fibre"; (3) the "free tissue" i.e. the tissue particles floating freely in the flume water and not passing through a thin cloth used as a sieve; (4) the "waste water", i.e. everything in the waste with the exception of the first three components. The "waste water" thus defined comprises substances in solution as derived from the cell sap of the leaves, colloidal leaf particles and other coarser particles which can pass through a cloth used as a sieve. These four distinctions are not made for theoretical reasons but are based on the practice of waste utilization.

Presuming effective milling and for an average of leaves of all sorts of age, said four waste components amount to the following approximate percentages of "fibre" on the basis of 10 per cent moisture content, i.e. the usual moisture content of commercial fibre: "waste fibre" 25 per cent, "adherent tissue" 50 per cent, "free tissue" 85 per cent, "waste water" 150 per cent; total 310 per cent.

In this denotation and on the basis of 10 per cent water content the leaf is made up from 100 parts of "fibre" with 310 parts of waste, the "fibre" thus constituting about 24.4 per cent of the dry leaf matter, which is equivalent to nearly 4 per cent of the fresh leaf for most Java and Sumatra areas.

It will be seen that the "waste water" constitutes more than half of the plant-food bearing material in the waste, if it is only noticed that the "waste fibre" contains nearly no nitrogen, that its ash content is only about one-tenth of same in the other waste components, whereas its bulk is relatively small. The importance of the "waste water" from a plant-food point of view is further enhanced by the fact that the chief plant-food substances are contained to a higher proportion in the "waste water" than in the two sorts of tissue.

Although a rather wide range of variation may occur in the plant-food proportions of the wastes of various origin, it might be useful to quote here the respective figures for an example of rather average conditions for Java and Sumatra. These figures as reported in Table I apply to a field with a "fibre" production of an average of two tons per ha. per year, that is to say including the unproductive period of the cycle. We may consider

such a production as reasonable, although not at all high for Java and Sumatra, where fields with yearly productions of three tons per ha. are not uncommon. It may be explained here, that in Java and Sumatra a sisal field is cleared and replanted when a certain proportion of the sisal plants, usually 50 per cent, have perished. In a case of a yearly production of two tons per ha. it then takes after replanting about one-and-a-half years before the field is cut, cutting from then on being repeated twice a year, so that altogether twelve to thirteen cuttings will be performed during the whole cycle of eight years. In such a cycle the total production will be eight times two tons, i.e. sixteen tons of "fibre" per ha. In some of the eight years the production is, of course, higher and in other years lower than the said average of two tons per ha. The figures of Table I can thus be taken as applying to an estate with eight sisal fields of equal size, each field during eight years with a yearly average production of two tons of "fibre", and the fields having been planted in consecutive years. In this table the plant-food content of the "fibre" has not been recorded as it cannot be recovered, as well as that of the "waste fibre" which either cannot be recovered or is of relatively small importance.

From Table I it may be seen that the manurial value of the waste is quite large. In the given example it is £5/4/2 per ton of produced "fibre", even if nothing is accounted for magnesia, lime, the organic matter as such and many other less important constituents of the waste not mentioned in Table I. By far the largest part of this value is comprised, as already explained, in the "waste water".

TABLE I

Chief average yearly plant food contents in kg. per ha. in the waste of a sisal field, producing on an average 2 tons of fibre per year per ha., together with some other data.

All data are based on a moisture content of 10 per cent.

Waste Components	Bulk of Waste	Nitrogen (N)	Phosphor (P_2O_5)	Potassium (K_2O)	Magnesia (MgO)	Lime (CaO)	Sugars	$N + P_2O_5 + K_2O$
Adherent tissue	1,000	9	4	7	9	30	—	20
Free tissue ..	1,700	18	8	15	16	51	—	41
Waste water ..	3,000	47	39	97	61	132	185	183
Total	—	74	51	119	86	213	—	244
Waste fibre ..	500	Approximate manurial money value on the basis of artificial manure prices during 1937 in Java and Sumatra						
Total waste ..	6,200	$\begin{array}{r} \text{£ s. d.} \\ \text{N} \quad \dots \quad 3 \ 5 \ 9 \\ \text{P}_2\text{O}_5 \quad \dots \quad 1 \ 2 \ 8 \\ \text{K}_2\text{O} \quad \dots \quad 5 \ 5 \ 9 \end{array}$						
Fibre ..	2,000							
Total leaf ..	8,200	Total .. <u>9 14 2</u>						

It may be useful for comparison with the manurial value of the waste to record in Table II its energy value, if the waste is used as fuel.

TABLE II

Energy recoverable by combustion from the waste inclusive of waste fibre but exclusive of waste water per ha. per year, of a sisal field producing on an average 2 tons of fibre per ha. per year, together with some other data.

Moisture Content of Waste	Gram Calories	K.W.H. Equivalent under Conditions of Practice
Per cent		
0	14,384,000 (theoretical)	—
30	8,769,600 (in practice)	1,200
50	7,516,800 ..	1,040
65	4,823,280 ..	665

Energy required in sisal factory per 2 tons of fibre produced, as an example for Java and Sumatra conditions.

	K.W.H.
For decorticating of the leaf ..	350
For centrifugalizing, pressing, light, etc.	250
Equivalent of steam for artificial drying	280
Total ..	880

It will be seen from Table II that, supposing the waste can be dried sufficiently, it is possible to recover from the waste as accounted for in Table II, all the energy which may be required in the sisal factory and even more than that. The value in money of the energy obtainable from the waste, say of the 1040 K.W.H. in the case of 50 per cent moisture content, should be computed on the basis of the price paid for fuel, which under the conditions considered, could equally supply this amount of energy. If the following should be accepted under Java and Sumatra conditions, viz. Sh. 0.09 for 1 kg. of heavy oil and should it further be assumed that 0.4 kg. of such oil are required to produce 1 K.W.H. of energy, said value in money is £1/17/5, or £0/18/11 per ton of "fibre" produced. To this figure should, however, be added the value of the manure recoverable from the ash obtained in combusting the waste. About the half of the K_2O and about two-thirds of the P_2O_5 contained in the waste burnt, is in practice found in the

waste ash. Their amounts may be estimated at 6 kg. K₂O plus 4 kg. P₂O₅ per ton of "fibre" produced, and their 1937 value for Java and Sumatra conditions at £0/7/1. Thus the total value of the waste used as fuel, as accounted for in Table II, may be put at £1/6/0. The manurial value of the same waste, used directly as manure, should be compared with this figure. If "waste fibre" is considered to have no manurial value, the N, P₂O₅ and K₂O contents of that same waste per ton of "fibre" produced, can be estimated at 13.5 kg., 5 kg. and 6 kg. respectively, with a total value under 1937 Java and Sumatra conditions of £1/4/5. This figure shows a slight advantage of the fuel utilization. If, however, the soil of the estate concerned is in need of organic matter as such, or is in need of humus, there should be no hesitation in utilizing the waste as manure, if this is possible under the given estate conditions.

In many sisal factories in the Dutch East Indies wood is used as fuel. About 3½ tons of firewood of reasonable quality are required to produce the energy of 1,040 K.W.H., i.e. the amount of energy under consideration, according to Table II. A reasonable price paid at present for such firewood by sisal factories in the Dutch East Indies is about £0/4/5 per ton, or £0/15/6 per 1,040 K.W.H., or £0/8/0 per ton of "fibre" produced. The firewood ash contains also some manurial value, which can in general be estimated at one quarter of same of the equivalent sisal waste used as fuel, i.e. at £0/1/10 per ton of "fibre" produced. The costs for obtaining the firewood must be diminished by this figure to obtain the real costs spent on firewood, viz. £0/6/2 per ton of "fibre" produced. Therefore in this case of firewood it is undoubtedly much more economic to use the waste under con-

sideration as manure, as its value is estimated at £1/4/7, at least if the sisal land under consideration is in need of manure.

As in general the Dutch East Indies sisal soils are badly in need of manure, with a few exceptions which soon will follow, it may be said in general that whatever the type of fuel used, it would be wiser to use the waste as manure than as fuel.

The exact balance of economy between the alternatives of using the waste as manure or as fuel is however dependent upon various local conditions, the chief points being: (1) the means available for recovering wholly or in part the manurial value from the waste; (2) the local needs for the various plant-food constituents of the waste; (3) the means available for recovering the fuel value from the waste; (4) the local needs for energy from waste; (5) the local costs for obtaining the required energy from other sources than waste; (6) the means available for working the "waste fibre" into "waste tow". Some of these points will be discussed later.

Let us now return to the East Java sisal estate with a 6,000 tons yearly "fibre" output. When the author arrived at this estate in 1918 the waste arrangement inside the factory was as described already for nearly all Java and Sumatra sisal factories. The waste left the factory by flume, mixed with a large volume of water. The flume was a narrow deep concrete channel which conducted the waste over a distance of about one-third of a mile to large basins dug in the soil, the dug out soil having been spread flat around the basins. There was an arrangement to conduct the waste at wish into the various single basins, which were connected with one another by a simple type of sluice. In the basins most of the coarse components of the waste settled,

namely the "waste fibre" with the "adherent tissue" and part of the "free tissue", whereas the "waste water" with part of the "free tissue" ran out into the next basin and finally into a small river, where it mixed with the river water. Thus according to Table I, in this case about four-fifths of the most important plant-food constituents of the waste ran directly into the river. The water of this river was further down used for irrigating native rice fields and sugar-cane fields, the latter belonging to the same company as owned the sisal factory, whereas said native rice fields constituted for somewhat more than a year out of every three, the sugar cane fields. Thus the plant-food running into the river was not just lost for the millers of the sisal, although its recovery was not only very imperfect but also quite incidental. Often, too heavy a plant-food content of the irrigation water caused trouble in the cane fields as well as in the rice fields by too strong vegetative growth, resulting in bad grain development in rice or in low sugar content of the cane. Sometimes complaints of the native rice growers were the result. It may even be said that, had it been possible to keep said river free from sisal waste, e.g. by running the waste into a land depression or into the sea, this probably would have been done. It is the author's opinion, however, that the area irrigated with the "polluted" river water has been continually extracting a considerable amount of fertility from it, a fertility however which was not conducted into its best paths.

The coarse waste as settled in the basins was as much as possible recovered for fuel. For this purpose the waste was left for a considerable time in the basins. This was done automatically by the native labourers who recovered the fuel on a piece-work basis. As long as sisal

tissue is alive, it dries extremely slowly and it lasts very long before sisal tissue dies if it is kept lying in situations as on the banks of said basins. The fastest method of killing it is just to leave it in such basins, as there fermentation soon sets in, whereby the tissue of the deeper layers is killed rather quickly. In this fermentation process the fibrous material was not much attacked but the tissue was considerably so. The plant-food freed in this process left finally the basins into the river where it enriched again the irrigation water and thus contributed in some way to the fertility of the area under irrigation from this river.

When the fermentation of the coarse waste in the basins had sufficiently advanced to make it workable, i.e. sun-dryable, the labourers who judged this stage by experience, drew the remaining coarse waste onto the bank of the basins, where it was sun-dried, loaded onto trucks and carried along a narrow-gauge rail track down to the boiler place of the sisal factory. It served here as fuel for the production of steam required in the mechanical fibre dryers, the decortication in this factory being done with power from Diesel motors. The fuel recovered consisted of the "waste fibre" plus about a quarter of the "adherent tissue". In accordance with Table I and on the basis of its moisture content of about 30 per cent, it weighed about 791 kg. per two tons of "fibre" produced, i.e. 0.4 kg. per kg. of "fibre" produced. As 1 kg. of the fuel so obtained yielded about 3 kg. of steam, so about 1.2 kg. of steam was available for drying 1 kg. of "fibre" produced, which is all that is required for this drying.

As has already been explained, part of the "free tissue" and about one-half of the "adherent tissue" were fermented in the basins and went into the river

either as free plant-food or as partly decomposed organic matter, besides of course the CO₂ evolved in the fermentation process, which disappeared into the atmosphere. About a quarter of the "adherent tissue" became fuel together with the "waste fibre", whereas another quarter of the "adherent tissue" remained on the basin banks as it fell out in the drying process. The remaining undecomposed "free tissue" settled on the bottom of the basins. After some period when too much of this peaty material had accumulated on the bottom of a basin, the basin was run dry. The peaty material was laid out on the banks of the basin and sun-dried. It was then carried to the tapioca factory of the same estate together with the quarter of the "adherent tissue" deposited on the basin banks. In the tapioca factory it was blown with a fan into the furnace of a steam boiler, where it was combusted in the same way as heavy oil. It was thus an excellent fuel. Its value can be estimated at about 125 K.W.H., whereas other fuel recovered was equivalent to about 115 K.W.H. per ton of "fibre" produced.

From this description it appears that already as long ago as twenty years at this estate a reasonable scheme of waste recovery was in working, although the recovery was only in part and, as regards plant-food, not well directed or even quite incidental.

The real cause of this system had been the impossibility of running all the waste, more especially the "waste fibre", into the river, whereas no land depression or ravine was available to get rid of it. So it happened that at the same time the same company did not follow this or a similar waste recovery system at its other sisal estate not far away, where a suitable ravine was at disposal to run the waste away.

In Mid-Java there were and still are a number of sisal and cantala estates of small size, the largest being about 1500 ha. At a few of these something was and still is being done with the waste in a similar way as described in the foregoing for an East Java estate. In most cases the largest part of the plant-food in the waste finally flows into some river. As a rule the water of such river is used for irrigation purposes of rice and sugar cane fields. It is hardly ever the sisal miller who benefits from the plant-food in this irrigation water. One case, which the author studied in detail, is rather unique and not at all uneconomic from a plant-food recovery point of view, although also in this case the plant-food does not return to the sisal soils, nor has the system been planned in advance. It is economic only by chance.

At this estate then the waste runs by a rather steep flume to a piece of rather sloping land on a ravine side. The extent of the piece is about an acre. Here all the coarse waste accumulates on the slope, nothing being recovered by the sisal miller. The "waste water" soaks through the waste heap and runs below the layer of coarse waste down the slope, like water running at the bottom of a glacier. The deeper layers of the coarse waste are gradually decomposing and the decomposed soluble matter and other fine particles run, mixed together with the "waste water", down the slope underneath the coarse waste. The waste heap increases at the top but shrinks at the bottom, resulting in a balance as to volume, which was already reached long ago. Furthermore the coarse waste is gradually creeping not only down the slope but also to the left and to the right. Thus a broad, rather shallow heap of almost constant depth and extent has established itself, from which at the

bottom a rather constant stream of water is running, containing much soluble plant-food and fine to rather fine partly decomposed organic matter. This material runs into a river at the bottom of the slope, where it fertilizes the water of this river, which is in constant use for irrigating of rice fields. Thus this fertile irrigation water which quite incidentally is of sufficiently large volume not to be too overloaded with plant-food, is quite a blessing to the natives deriving the irrigation water for their rice fields from this river. As explained already above, the whole system is quite a chance one, but it is not at all bad from a plant-food recovery point of view. If this estate would only pump up the stream of plant-food at the bottom of its waste heap, it could recover to a considerable extent the lost fertility of its exhausted sisal soils. This way of recovery could also at other estates be developed into a good, economic plant-food recovery system.

Another example of more or less incidental waste utilization may be mentioned in regard to a large sisal estate in West Java, opened in 1923. During the first three years of this estate's existence the "waste water", plus the "free tissue" dispersed in it, ran into the sea. The "waste fibre" and the "adherent tissue" were drawn out from the waste flume by hooks attached to an endless chain, running on a sloping conveyor. From the top of this conveyor said waste was dropped into narrow-gauge rail trucks, and in these trucks it was carried to a waste heap on level land at some distance from the factory. After said period of three years a roller plant was erected at this estate, to recover the "waste fibre" plus the "adherent tissue" as fuel by purely mechanical means. The steam boiler firing once having been arranged in

accordance with the characteristics of the waste fuel, it became now also possible to utilize the material of the waste heap, which had been accumulated during the past years. This material had the advantage that it could be used at will, when it was most needed and when it could most easily be carried to the boiler place. It lasted nearly another three years before it was entirely finished.

Some loose spreading of this old waste on the top of the heap was enough to get it sufficiently sun-dried and it was of superior quality as fuel, because it became drier than the fresh waste fuel could be made by rolling. For this difference compare the energy obtained from the 30 per cent moisture-containing material with same of the 50 per cent moisture-containing material in Table II.

It may be pointed out here that such a waste heap, if sufficiently drained, could be used as a regular system of fuel recovery from the "waste fibre" plus the "adherent tissue". Transport of the wet, fresh substance by rail trucks is rather expensive, but if the estate's situation would allow it, the waste under consideration could be dropped from the conveyor as described above, into a flume where sufficient water should be added and by which it could be run into a tank. Some of such tanks would be required to allow the one tank when full to be drained and emptied at the same time as another tank would be filling. Somewhat sloping land would be most suitable for such purposes.

If the "waste fibre" plus the "adherent tissue" were not separated from the "waste water" plus the "free tissue" no conveyor as described above and no additional flume water would be required and the waste heap would become identical with the heap on the ravine side as

described for the Mid-Java estate, provided, of course, a sufficiently sloping piece of land would be available. From the top of such a waste heap fuel could be collected, and simultaneously the effluent at the bottom of the heap could be recovered as manure.

If everything were the same as in the last instance, but only flat or slightly sloping land were available, the waste could be run into tanks and a system could be developed very similar to the one described above for the East Java estate. Also in such a case fuel recovery could go hand in hand with manure recovery.

When in the case of the West Java estate as described above, the old waste heap had been used as much as possible for fuel during the course of some three years, it appeared that the lower layers of the waste heap had been composted. This compost was in due course used as manure in sisal fields. The author made a study of the changes which had occurred in the soil underneath this waste heap and it was found that the plant-food

in this soil had enormously increased as compared with a fresh forest soil, which could be considered as representative of the original soil under the waste heap.

Table III shows the chief analytical results obtained. The first line of data refers to the forest soil, as representative of this estate. Herewith should be compared the second and third lines of data. The second line refers to the 10 cm. top layer of the soil under the waste heap and the third line to the soil at the same place, but taken from the layer of 40 to 50 cm. below the surface. One sees all the food values of the top layer under the heap increased enormously, and almost in the same degree those of the deep layer. This latter fact means that the downward seeping of the food substances has already proceeded very far, much too far as a matter of fact for sisal whose effective food absorbing roots go in this soil only about 25 cm. deep. If therefore one would like to manure sisal land by depositing upon it as a mulch waste as under consideration, i.e. "waste

TABLE III

SOME ANALYTICAL DATA OF SOILS UNDER A SISAL WASTE HEAP AND UNDER SISAL STUMP HEAPS

The data of columns 1 to 3 are expressed in mgr. equivalents per 100 c.c. of soil, the data of the columns 4 to 10 in kg. per ha. per soil layer of 10 cm. thick.

	Capacity for absorbing bases	Actual bases absorbed	Saturation with bases	Absorbed			P_2O_5		Total N	Carbon	pH	C/N Ratio
				K ₂ O	CaO	MgO	Total	Easily available				
10 cm. top layer of fresh forest soil ..	25.1	18.8	75	730	2,630	570	1,280	32	2,100	28,000	5.6	13.3
10 cm. top layer of waste heap soil ..	40.6	39.9	98	4,550	3,670	3,410	3,970	1,844	4,180	17,200	8.5	4.1
40 to 50 cm. deep layer of waste heap soil	36.9	35.6	96	5,650	2,900	1,880	1,140	119	2,250	11,500	8.4	5.1
10 cm. top layer of soil under heap of sisal stumps, with lime	—	—	—	615	6,380	1,679	—	265	2,648	—	7.8	—
10 cm. top layer of soil under heap of sisal stumps, without lime	—	—	—	1,152	4,020	1,820	—	442	3,010	—	7.3	—

For the analytical methods used, see Dr. P. W. E. Vageler, "De Analysemethoden van het Agrogeologisch Laboratorium van het Proefstation voor Thee, te Buitenzorg." Archief voor de Theecultuur in Nederlandsch Indie, Buitenzorg, January, 1928, No. 2.

"fibre" plus "adherent tissue" the layer of waste should be taken very much thinner than in the present case, wherein the original waste, if no shrinkage had occurred, would have been many metres thick. A layer of 10 to 20 cm. thick of such waste, spread out as a mulch, would enhance the soil fertility of exhausted sisal land largely. Thus, if only local conditions would allow of this, one could spread such waste over sufficiently large areas as a mulch and thus benefit largely from its manurial value. When rain and fermentation had separated the tissue from the fibre, one could afterwards recover the fibre as fuel, because this fibre contains relatively little plant food. In such a combined recovery scheme of plant-food as well as of fuel, the "waste water" would have to be used as plant-food in its own, separate way. How this can be done, will be shown later.

The first three lines of data in Table III show further many interesting details, all of which will not be discussed now. Here attention should be drawn only to the alkalinity of the soil under the waste heap as compared with the acidity of the original soil. Also the very low C/N ratios of the soils under the waste heap are very remarkable, especially so as these low ratios have not only been brought about by increased nitrogen-content but equally so by decreased carbon-content of the soil. Apparently the high nitrogen-addition has caused a rapid decomposition of the organic material of the original soil on account of the unstableness of a very low C/N ratio. It should be well understood that no organic matter of the waste has been worked into the soil, but that all such organic matter was taken away from the top of the soil before sampling took place.

After the waste heap under discussion had been cleared away, the soil was planted with sisal. Its growth was excellent. Its cycle lasted only six years and its total cycle-production must have been about $22\frac{1}{2}$ tons of "fibre" per ha., which equals $3\frac{3}{4}$ tons per ha. per average cycle-year. These figures compare with 16.8 tons per ha. per cycle of eight years in the original fresh soil, which equals 2.1 tons per ha. per average cycle-year. Thus the yearly "fibre" production of the original fresh forest soil, which by itself was reasonable, has been augmented more than 50 per cent by the plant-food, soaked from the waste heap into the soil under it.

For reasons of comparison some more analytical data have been added in Table III which data belong to two soils, sampled from the top soil layer of 10 cm. from underneath two heaps of sisal stumps, which were put up with a view of finding whether it is possible to compost sisal stumps in such a way, with and without additional lime. In each case 4,000 stumps, weighing fresh about 72 tons, had been stacked about $2\frac{1}{2}$ meters high on a soil surface of about 120 m^2 . To one of the heaps $1\frac{1}{4}$ tons of lime, spread between the stumps, had been added. The soil samples were taken two years after stacking the stumps. At that time the stumps had undergone the composting process to a large extent, although the compost was rather coarse.

As may be seen from Table III much plant food must have been washed out from the stumps into the underlying soil in a similar way as from the waste on the waste heap. The additional lime in the one of the stump heaps has however retained all the potassium and much of the "available phosphorus" in the compost, which in the case of potassium

seems remarkable. Otherwise the data for stumps soil resemble in principle closely those for waste top soil. This is of course not unexpected as stump and waste material are in principle very similar.

By the way it may be inserted here that the data of Table III shed some light on the beneficial effects of mulching in general.

A study of the data as prescribed in the tables will make one understand that the author became convinced at an early date of the high potential value of sisal waste. Up to the middle of the twenties the only really intended and well planned sisal waste utilization in Java and Sumatra was as fuel. The author understood then, that the ideal waste utilization would be first to recover the "waste fibre" as "waste tow" since fibre contains very little plant food and secondly to utilize all the rest as manure; the utilization would prove uneconomic, i.e. under exceptional conditions.

This ideal has now materialized, at least approximately, at one estate, although the path followed to reach this goal has not been a straight one. In the Dutch East Indies the recovery of the "waste fibre" plus the "adherent tissue" as fuel by purely mechanical means has preceded the recovery of "waste tow".

With this type of fuel recovery Sumatra was in the twenties in advance of Java, just as later on Sumatra was the first to recover by mechanical means the "waste tow". The reason for this lies in the fact that most of the Sumatra fibre-production is concentrated in few very large factories with ample mechanical and financial means.

It may be interesting to record in Table IV a few data showing the short and fast

development of the Sumatra sisal industry. For comparison some Java and Africa data are added in this table.

TABLE IV
SISAL EXPORTS IN SOME YEARS FROM
SOME COUNTRIES

	First year in which about 2,000 tons of were exported	Total approxi- mate sisal exports in 1935 plus 1936
	Tons	
Tanganyika ..	1906	163,500
Java ..	1911	59,700
Kenya ..	1914	68,700
Sumatra ..	1921	100,900

The Sumatra figure includes some waste tow and also some Manila hemp, which is manufactured together with and in the same way as sisal, representing the so-called "Deco" of the Philippine Islands.

The concentration of production and therewith combined availability of technical performance will be understood from the fact that nearly all the Sumatra sisal is produced by only five estates, of which two were producing in 1935 and in 1936 only a few thousand tons each, the three other ones forming one single complex in the Siantar region of the East Coast of Sumatra.

The mechanical plants in Java and Sumatra for recovering "waste fibre" plus "adherent tissue" as fuel, work generally as follows: hooks attached to an endless chain draw the waste from the waste flume as this reaches outside the sisal factory proper. From the top of a usually sloping conveyor this waste is dropped on to a carrier, which conducts it into a set of rollers, similar to sugar-cane rollers. In some cases only one single set of rollers is used, in others the waste after having passed the first set, is conveyed into a second set, where a stronger pressure is applied.

If two sets of rollers are used, the first presses out the sap and water from the

waste to such an extent as to produce a material with 60 per cent to 70 per cent moisture content. The second set of rollers then reduces this moisture percentage to about 50 per cent. The resulting material, if used under a boiler with the right type of step grating, is a suitable fuel without any further treatment. It yields under suitable conditions of practice about 1.8 kg. of steam per 1 kg. of material, i.e. 3.6 kg. of steam per 1 kg. of dry matter.

According to Table I 500 kg. of "waste fibre" plus 1000 kg. of "adherent tissue" are obtained together with 2000 kg. of "fibre", i.e. altogether 1500 kg. of these waste components on a basis of 10 per cent moisture content. This makes on a basis of 50 per cent moisture content 2700 kg., which can yield, according to the above data under conditions of practice about 4860 kg. of steam equivalent to about 486 K.W.H. According to Table II an equivalent of 280 K.W.H. are required for drying mechanically 2000 kg. of "fibre", thus leaving in our example another 206 K.W.H. for decortication, centrifugalizing, etc., i.e. about 34 per cent of all the energy required for these other processes. For sisal factories where no mechanical but sun-drying is practised and where also some other energy as mentioned in Table II, e.g. for centrifugalizing is not required, the 486 K.W.H. would go very far in supplying all the energy required. In the large Java and Sumatra factories, however, where waste rollers are in use, everything is being done mechanically. At these estates with an average yearly rainfall of up to 120 in. the factories have, with the exception of one month stop for the purpose of overhauling the machinery, to work all the year round, thus also during the wet monsoon when sun-drying the "fibre" would be an impossibility.

If conditions would allow of sun-drying the rolled waste, with its 50 per cent moisture content, thereby the moisture content of the resulting material could be reduced to about 30 per cent, the steam yield of 1 kg. of such material would be about 3 kg. or about 4.3 kg. per 1 kg. of dry matter. In such case the total steam output from the twice rolled and afterwards sun-dried "waste fibre" plus "adherent tissue" would amount to about 5800 kg. with a K.W.H. equivalent under conditions of practice of about 580, i.e. 65 per cent of all the energy required in the factory if everything should be worked mechanically, and nearly 100 per cent if the "fibre" should be sun-dried. As far as the author knows such system however has never been practised in Java or Sumatra, where it would be impossible during the wet monsoon.

There is still another possibility of increasing the steam yielding capacity of the waste rolled to 50 per cent moisture content. It can be stacked in large heaps and there left to ferment. Hereby some of the organic material of the waste is oxydized to CO_2 . The heat developed by fermentation dries the remaining waste to such an extent that the loss of combustible organic matter is more than counterbalanced by the improved steam yielding capacity of the remaining drier material. This method of fermentation has however apparently only incidentally been used in the Dutch East Indies.

If only one set of rollers is used and the resulting rolled material contains between 60 per cent and 70 per cent moisture, the yield of energy of such material by combustion is too low to be economic. Table II shows the low energy yielding capacity of such material. In such case something must be done to decrease the moisture content of the rolled material.

The best method of drying such material would be sun-drying, if only estate conditions would allow of this. In Java and Sumatra this method is apparently, however, not applied, and could not be applied during the wet season if anything like regularity of fuel supply from this waste should be desired. If a factory mills the leaf only at day time, the single set of rollers could be used at night time to remill the waste which has already been rolled once during the day time, at least if the local conditions of energy-delivering as required for rolling, would allow this. Two other methods are possible to reduce the moisture content of the once rolled waste under consideration. The first is to ferment the material of 60 per cent to 70 per cent moisture content in large heaps. This method has as a matter of fact been followed as an emergency measure for some time at least at one factory at Java. The other method, which is followed by one of the smaller factories of Sumatra, is to compress the rolled material of some 65 per cent moisture content in bales with baling presses as used for baling sugar cane residue. These bales are thereafter stacked in a shed and left for some time to ferment. After sufficient fermentation the resulting material has become an excellent fuel, probably yielding in total more energy than the otherwise twice rolled and not further treated material would have yielded.

Up to now only "waste fibre" and "adherent tissue" were considered in detail as a source of fuel. In Table II also the "free tissue" was included in the figure for energy recoverable from waste. Table I shows that this component of the waste is larger than the two other components together, viz. 1700 kg. as against 1500 kg. per 2000 kg. of "fibre" produced, all expressed on a 10 per cent moisture con-

tent basis. Further it appears from Table II, that in case all these three waste components could and should be recovered as fuel, even with a moisture content of 50 per cent, plenty of energy for every task of the sisal factory would be available. The difficulty is, however, how to dry the "free tissue". If this waste component as dispersed in the "waste water", i.e. after the extraction of the two other waste components, is run into a tank, which afterwards is drained, then the settled substance in the tank, i.e. the "free tissue" plus some of the coarser matter of the "waste water", contains only 10 per cent of dry matter per unit volume. It appears to be extremely difficult to eliminate by mechanical means the 89 per cent of the water from this material, after which manipulation the remaining material would be left with a moisture content of 50 per cent and thus would constitute a good fuel. Apparently a procedure to this effect has never been applied in Java or Sumatra. The author believes that it would not pay from a fuel point of view, as too much energy would be involved in such mechanical water extraction process. Also sun-drying of the material in question is not easy, as the fresh tissue cells are of an extreme vitality and the tissue cannot be dried before the cells have been killed. One would have to spread the tissue on the sides of the said tank in layers of a few centimetres only, to allow of sun-drying in less than a week. Enormous areas would be required for such drying and much soil would become mixed with the fuel, with resulting baking in the boiler furnace. The only practical way would be to drain the tanks well after filling and to leave the tissue in them untouched for a considerable time to kill the tissue cells by eventual fermentation. In said process a considerable part of the organic matter

in the tissue, perhaps 50 per cent, would have to be fermented into evaporated CO₂ before sun-drying on the sides of the tanks could be accomplished in a reasonably short time. As a matter of fact this procedure was followed to a small extent in the first mentioned East Java estate case. Also the discussed system of the Middle-Java estate could be exploited to some extent with a similar effect. As far as the author is aware such method of fuel recovery from "free tissue" is at present not applied as a real system in Java or Sumatra.

If 50 per cent of the material as discussed now, would be decomposed in tanks by fermentation, the manurial value of the decomposed 50 per cent would be recovered in the drain water from the tanks and could be used, mixed with the other drained off "waste water". If after decomposition of 50 per cent of the material, the fuel recovered from the remaining material would contain 50 per cent moisture, the energy recoverable from it would be about 1530 times 1.8 kg. of steam, i.e. 2754 kg., equivalent under conditions of practice to about 275 K.W.H. Together with the 486 K.W.H. from "waste fibre" plus "adherent tissue", equally containing 50 per cent moisture, this would make, according to Table II, about 86 per cent of all energy required in a sisal factory, where milling takes place by mechanical means only. The said sum of energy would be more than enough for a factory sun-drying its "fibre". If the moisture content of our tank material could be reduced to 30 per cent and also the "waste fibre" plus the "adherent tissue" be dried to the same extent, the total energy from these three waste components together would amount under conditions of practice to 298 plus 580 K.W.H., which would be, according to

Table II, just about the amount of energy required for working everything in the sisal factory mechanically.

As regards all the methods described for fuel recovery from sisal waste either as practised or as possible, one should well remember the earlier statement for Java and Sumatra conditions, that in general it will be more economic to utilize sisal tissue of any description as manure, than to use it as fuel. How this statement works out for the various waste components and under different conditions will be dealt with later in detail.

As to the "waste fibre" it will also only exceptionally be economic to use this as fuel. The working of this waste component into "waste tow" will in general be much more economic. If the 1937 prices for good "waste tow" and for heavy oil as fuel are taken as a basis of comparison and further the data of Table I are applied, the following calculation results. Together with one ton of "fibre" on the one hand 250 kg. of "waste tow" can be prepared with a net profit of about £4/0/0, if no general expenditure is calculated in its cost price. On the other hand this "waste fibre" can yield, on a basis of 30 per cent moisture content, which is a favourable basis, 88 K.W.H., which equally could be produced by 38 kg. of heavy oil, which is a relatively expensive fuel, costing under Java and Sumatra conditions about Sh. 3. In fact the fuel value of this waste is even less, as no costs have been calculated for recovering the fuel from the waste.

To use "waste fibre" as fuel and not as a source of "waste tow" would only be economic if the 1937 price of some £15 per ton for "waste tow" would fall to less than half, or if "waste tow" would be unsaleable, as might occur in very bad slump times.

As already mentioned, the recovery of fuel from "waste fibre" by purely mechanical means, has in Java and Sumatra preceded its recovery as "waste tow". The result has been that the rollers used in the earlier fuel recovery process have been used also in the equipment for "waste tow" recovery. In principle they can however be dispensed with in the latter process. This paper is not meant as discussion for technical constructions and will thus leave details of such constructions aside. Only some actually applied and some potential principles involved in the "waste tow" recovery process will be mentioned here. The very first point in "waste tow" recovery is to obtain as purely white a tow as possible. To this effect the plant saps and other matter of the "waste water", which are retained by the "waste fibre" plus the "adherent tissue" as they are extracted from the waste flume, should be washed out as thoroughly as possible in the earliest possible stage of the process. The best way would even be to do this directly after decortication of the leaf, that is to say, before the "waste fibre" can have been for any considerable time in contact with the plant saps of the "waste water". Rolling, if applied, should therefore come after this preliminary washing. Also then however, rolling will always result in a somewhat discoloured tow as no preliminary washing will take away all of the "adherent tissue", but the saps wrung from this tissue by the rolling will cause some discolouring of the final "waste tow". Rolling may, however, be useful in so far as it loosens to some extent the "adherent tissue" from the "waste fibre" and thus facilitates the discarding of the former. This discarding of the "adherent tissue" from the "waste fibre" is usually done by some sort of coarse carding machine combined with a shaking de-

vice, but it can also be accomplished by frequent washing with water under heavy pressure, the material being continually turned over and over with a view to exposing the detached tissue particles. After a set of operations as described, a considerable part of the "adherent tissue" is still mixed up with the "waste fibre". It is supposed to be possible to separate the former entirely from the latter by a purely mechanical process of rubbing, shaking and carding. As things are at present, at least as far as the author is aware, the remaining "adherent tissue" has to be loosened from the "waste fibre" by a retting process, in which soap can be used to improve the results. After retting it seems to be possible to remove the loosened tissue particles and of course the soluble and fine matter from the "waste fibre" by frequent washing with water under heavy pressure. The usual process is however to wash the retted material preliminarily and then to eliminate the remaining tissue particles by some coarse carding and shaking device. Hereafter follows centrifugalizing, drying and finally carding with one of the real carding machines as are to be found on the market.

If in the process of "waste tow" recovery no other mechanical means were applied than washing combined with retting, then the "adherent tissue" would leave the "waste fibre" dispersed in water. Potentially it could then be recovered as fuel together with the "free tissue", which procedure appears however not to be followed in the Dutch East Indies. The best way of utilizing this loosened "adherent tissue", which is dispersed in water, would as a rule be to use it as manure together with the "free tissue" equally dispersed in water.

If on the other hand after a preliminary washing of the "adherent tissue" in

the process of "waste tow" recovery only dry means are applied, occasionally intervened by retting, then the "adherent tissue" is obtained with a moisture content of 50 per cent or somewhat more. It could then be used as fuel. As a rule, however, it would be better to use tissue as manure. As such it could be applied as a mulch or turned in the soil of the sisal fields after transportation with the usual means of estate transport. If used as manure, it will, however, be as a rule more economic and certainly much easier to run it into the "waste water" flume behind the point where the "waste fibre" plus the "adherent tissue" are taken from the waste flume. How this "waste water" plus "free tissue" plus detached "adherent tissue" can be dealt with as a manure, will be discussed more fully later on.

It should be mentioned here that in a Sumatra case, where no "waste tow" is prepared but where a set of rollers is in use for recovering fuel from the "waste fibre" plus the "adherent tissue", part of the loosened tissue is separated by a shaking device from the obtained fuel, and then run by a chute into the "waste water" flume, thus to be conducted to the sisal fields, where it is used as a manure. In a similar case in Java a coarse carding machine was used to separate such loosened tissue from the fuel. In the latter case this tissue was carried with rail trucks to the sisal fields, where it was turned in the soil as manure.

Two fuel points are still to be discussed, viz. first the economy in the alternative of using the detached "adherent tissue" as separately obtained in the "waste tow" process either as fuel or as manure, and secondly said economy regarding the original "free tissue".

If the "adherent tissue" is obtained free in the dry stage of a "waste tow"

recovery process, its moisture content is at least 50 per cent. Taking 50 per cent moisture content as a basis, its fuel value is per ton of "fibre" produced, according to earlier data, 900 times 1.8 kg. of steam, equivalent under conditions of practice to about 162 K.W.H., which can be produced also from 65 kg. heavy oil, costing at present under Java and Sumatra conditions about £0/5/10. This figure should be compared with the manurial value of this waste component, less the manurial value of the ash of this waste, if used as fuel. According to earlier data the difference of these two values is the value of 4.5 kg. N, 0.7 kg. P₂O₅ and 1.8 kg. K₂O per ton of "fibre" produced, which under present Java and Sumatra conditions equals about £0/5/11. This value is practically equal to the figure for the value of heavy oil fuel. As however the manurial value has been computed quite conservatively and as a rule the humus principles in the tissue will be important to the sisal soil, the choice in this case should as a rule be in favour of the manurial value. This will be the more so, if local conditions allow the economic use of firewood instead of heavy oil, which indeed happens to be so in many cases of Java and Sumatra sisal estates.

If the data of Table I are studied, one will notice that the "free tissue" contains to a higher degree substances of manurial value than the "adherent tissue", because according to the accepted definition, the "adherent tissue" contains some fibrous material, which is lost in the process of "waste tow" recovery, and such fibrous material contains very little plant-food. Thus the above conclusions as arrived at for "adherent tissue" would apply in a somewhat stricter sense equally to "free tissue", if the "free tissue" could be recovered with the same 50 per cent mois-

ture content as the "adherent tissue" in the dry stage of a "waste tow" recovery process. Theoretically this is quite possible as explained already, even much lower moisture contents being obtainable. However, as also explained already, it would be difficult to practise such a procedure under Java and Sumatra conditions. It appears to be nowhere practised in Java and Sumatra, at least not systematically. Therefore the "free tissue" is in Java and Sumatra naturally and in general most economically used

as manure. If used thus, it is, if possible, applied to the sisal soils dispersed in the "waste water". But in some places where local land conditions forbid this method of application, it is sieved off from the "waste water", after "waste fibre" plus "adherent tissue" have already been separated from the waste. The sieved off "free tissue" is then, occasionally together with the separated "adherent tissue", carried in its wet condition to the sisal fields with the ordinary means of estate transport.

(To be continued.)

Reviews

SOIL EROSION, A MEMORANDUM

By E. HARRISON, C.M.G.

(The Crown Agents for the Colonies,
1937)

This paper is a review of the position in regard to soil erosion in Tanganyika Territory up to June 1937 and embodies reports from the Forestry, Veterinary, Education and Agricultural Departments and the Provincial Administrations. The Soil Erosion Committee decided soon after its appointment in 1931 that in the absence of considerable funds for direct attack on the problem endeavour should primarily be educative. It realized that a public opinion was necessary, induced either by demonstration and propaganda or by sheer necessity, before direct action could be taken. That considerable success has since been achieved by demonstrations and propaganda is shown in the second part of the paper, which outlines the position province by province.

It is stated that the whole Territory is not seriously endangered by man's disturbance of the land, for the cultivated or exposed area is only about one-thirtieth of the whole. This together with

the computed 7 per cent suffering from overstocking makes in all one-tenth of the Territory affected. Part of this tenth is not really menaced, but the author states that "there is a real haunting fear that essential land, tree cover and some water supplies are seriously threatened".

The doubts that have been cast on the progress of anti-erosion work in this country are attributed to ignorance of the magnitude of the task and the precise need for it in different areas. For example the problem on Kilimanjaro and in other mountainous areas is to cope with a heavy rainfall on steeply sloping land. In Sukumaland it is a very different one. There the conditions are semi-arid and one has to deal with soil desiccation and wind-erosion over a long period of the year, as well as sheet erosion during the heavy rains. Hence measures taken to control all forms of erosion must vary considerably in different areas. In addition these must be related to the nature of the local soil. A possible criticism of the paper is that the importance of a knowledge of soils is not sufficiently stressed.

But this is the technical, or one might even say the theoretical, side of the problem. The problem as a whole must be considered mainly from the administrator's point of view. Traditional tribal usages cannot be ignored. Often they can be simply modified to give useful results and occasionally the traditional method of land management is the best that could be devised. It is not easy at once to apply all the schemes and desirable practices over enormous areas: casual grass burning on hill-sides, leading to destruction of valuable bush and forest, overgrazing and trampling by stock, failure to plant trees, and shifting cultivations, especially on steep slopes, are all real difficulties which can only be overcome gradually. Already, however, many native authorities have adopted anti-erosion rules, while some are busy planting windbreaks or adopting contour windbreaks and declaring hillsides and hilltops as reserves not to be cultivated and to be grazed only during defined periods. One gathers that the position in regard to anti-erosion measures taken by non-natives is analogous, some planters taking precautions, others not.

Special reference is made to overstocking and a fairer popular conception of this difficulty is requested. The Director of Veterinary Services is quoted thus: "In spite of his abuse of his heritage, the native is more important than the land, and in spite of soil erosion, domestic animals are amongst a country's most important assets". Attention is drawn to the Veterinary Department's scheme to relieve overstocking by the expansion of a rotational grazing system, the multiplication of water supplies, the control of grass burning and a control of the type and numbers of stock that may use each of the units of grazing eventually demarcated and developed. The work of the Tsetse Research Department is also re-

ferred to, especially as to the settlement of fly-free areas and its attendant risks. The bearing of problems of native land tenure on soil management is stressed. One is impressed by the fact that the officers concerned are very much aware of the position, and that the remedies applied appear to be consistent with good government and a real appreciation of the intricacies of the problem.

W. E. C.

AFRICAN ARTS AND CRAFTS

By MARGARET TROWELL

(Longmans, Green and Co., 7s. 6d.)

This excellent and fascinating book, although written primarily for educationists, will repay also the attention of many who are interested in agriculture. After some introductory chapters on art and the theory of education, the author proceeds to describe many of the crafts which are practised in the African home-stead, such as basketry, pottery, net-making, and wood-carving. She has experience of several tribes in Kenya and Uganda, and in each case has described the methods of the best craftsmen in that particular work; in addition, several simple improvements are suggested which can be brought about by the application of more scientific methods. As well as this, certain crafts which are known to the East African native, such as spinning and weaving, are described. The whole is illustrated with a wealth of photographs and diagrams, and the illustrations are most lucid. Certain sections such as those on string-making and sack-making will be of immediate interest to many farmers, and in schools many of these subjects would fall almost as aptly into the agricultural as into the hand-work lesson. We must congratulate Mrs. Trowell on a fine production and on drawing attention to a subject which has been too much neglected. G. B. M.

Kapok

I—THE BOTANY AND AGRONOMY OF KAPOK

By P. J. GREENWAY, F.L.S., Systematic
Botanist, East African Agricultural
Research Station, Amani.

Certain trees in the genus *Ceiba* (*Bom-bacaceae*) produce fruits containing a mass of fine hairs (floss), which arise from the wall of the capsules and have the seeds buried in their midst. These hairs, which in nature assist in the distribution of the seeds, are known commercially as "Kapok" or "Silk Cotton" and are used for stuffing cushions, pillows, mattresses and similar articles. The hairs are cylindrical, from .6 to 1.2 inches long, formed of cells full of air, impermeable to moisture and extremely buoyant. For this reason a second important use for kapok is in the manufacture of buoys, life-belts and life-saving jackets. Kapok textiles are not strong and yarns made from it are not able to withstand strains; owing to their non-conducting character they might, however, be employed as an interlining in warm clothing.

BOTANY AND DISTRIBUTION

The term "kapok" has been used for the product of a number of different trees, but it should be restricted to the floss of *Ceiba pentandra* Gaertn. (syn. *Eriodendron anfractuosum* DC.). It is found in the hot moist tracts of Western and South India, in Burma, and is a common and widely distributed tree in Ceylon, where it grows from sea-level to about 2,500 feet, but gives the best results at low and intermediate elevations. In Malaya kapok trees are grown in considerable numbers by natives. It was cultivated in Mauritius but owing to the ravages of a beetle had to be discon-

tinued. It occurs in all the West African Colonies, in the evergreen and mixed deciduous forests as well as in rain forest, where it reaches a great size. In East Africa kapok has been cultivated on quite a large scale in Tanganyika Territory. It grows well in the coastal region of Kenya and in the Sudan. In Zanzibar it is planted as a boundary tree. It is found in most of the islands of the West Indies and is either wild or cultivated in Australasia.

Until recently the pan-tropical appearance of the species was thought to be the result of cultivation, the original home being perhaps America. But the American tree, *C. occidentale* Burkell, which was regarded as identical with the Asiatic species, differs in many points. It is not yet known how the two species differ economically. From observations in cultivation at Calcutta *C. occidentale* does not flower at the same time as the Asiatic *C. pentandra* and is shy of fruiting.

One authority says that the Arabs took the Asiatic tree to East Africa; but it is also found in West Africa, where the Arabs are not likely to have introduced it, and the Portuguese may have spread it to Asia from West Africa by way of East Africa.

C. pentandra is extremely variable, in the spininess of its stem, in habit of branching, in size of fruit (length of 4 inches to more than 15 inches having been recorded), in manner of opening (some on the tree and others dropping to the ground unopened) and in the length, colour and springiness of the floss.

By some authorities the following three varieties are recognized, but in

herbarium material they are very difficult to distinguish:—

(a) *Ceiba pentandra* var. *caribaea*, the West Indian form with irregular buttressed trunk and wide-spread branches and reddish flowers. This no doubt is *C. occidentale* Burkall.

(b) *C. pentandra* var. *indica*, the East Indian form with yellow flowers and smooth trunk. From this form the Java Kapok is obtained; it reaches a great size under natural conditions but in cultivation is usually seen as a slender tree up to about 50 feet high with horizontal branches arranged in tiers. It sheds its leaves in the dry season and the flowers appear just before, or at the same time as, the new leaves. The fruits are more or less oblong capsules, about 6 inches long and 2 inches in diameter at their greatest width.

(c) *C. pentandra* var. *africana*, the African form, has no especial characteristics and by some authorities is said to be "a cultivated race".

In Togoland where the Germans made a special study of the African *Ceiba pentandra*, four varieties were known, the best being called the "Togo Edelkapok". This has a straight fruit with a whiter and longer floss than a variety with a curved fruit. It was considered equal in quality to the very best Java Kapok. According to the Germans the Togo Edelkapok was planted on the roads of Mangu-Jendi before 1911. Mangu-Jendi (Mangu Gandu) is near the borders of the Northern Territories of the Gold Coast in Northern Togoland, and it is probable that the Edelkapok occurs throughout the whole area of the Mangu-Jendi district as well as in the Northern Territories of the Gold Coast.

In 1912 or 1913 seeds of the Togo Edelkapok were introduced to Amani, where there is a small plantation estab-

lished at Sigi. At the same time seeds of this variety were distributed to various planters in Tanganyika. In 1928 a further consignment of seeds was obtained from Togoland, through the kindness of a member of the Forestry Department of the Gold Coast. Trees from this seed are doing well at Sigi and are just beginning to fruit.

CULTIVATION

Commercial cultivation should only be attempted in a tropical climate. Though found wild or semi-wild from sea-level up to 3,000 to 4,000 feet, the best yield and quality of floss is obtained when the tree is grown at less than 1,500 feet. It attains its greatest development in the tropical rain forests of West Africa, yet owing to its deciduous habit can resist long periods of drought. The best conditions are abundant rain during the growing season and a dry period from the time the flowers are setting until the pods are harvested. Plantations should not be established in wind-swept situations, the quick growing branches being brittle and easily damaged by high winds. A well drained soil is necessary, and kapok will flourish on deep porous sandy loam such as is often found on alluvial flats along streams. In Java the finest kapok is produced on weathered volcanic soil.

The tree is usually propagated from seed, although cuttings can be rooted if vegetative propagation of a single strain is required. About 6 lb. of seed should be enough for 100 acres. It is sown in rows 10 to 12 inches apart in beds and watered in dry weather. The seeds only take a few days to germinate, and the seedlings should be shaded till 5 or 6 inches high. They must then be exposed to the sun to prevent them from becoming lanky. The young plants grow quickly and should be thinned out to 9 inches apart in the rows; when six to twelve months

old they should be planted in their permanent quarters. For this operation, which should only be done during showery weather, they should be topped and all their leaves removed.

Cuttings should not be of the current year's growth; their size may vary from $\frac{3}{4}$ inch to 2 inches or more in diameter and from 18 inches to 6 feet or more in length. In the Philippines the best results were obtained from the larger cuttings. The cuttings should be planted at once in the place they are to occupy permanently and inserted about 12 to 18 inches deep in the ground, according to their size.

Kapok is often planted irregularly as boundary and fence trees. In Java it has also been inter-planted between other crops such as coffee, cocoa, pepper and vanilla. In parts of Java and the Philippines kapok is grown as the sole plantation crop.

It has been suggested that where grown as a single crop the plants should be planted about 18 feet apart, which seems very close together. At Amani where the trees are growing at about 1,500 feet altitude they are planted 18 feet apart in the row and 24 feet between the rows. Even then their branches seem to be crowded into the tops of the surrounding trees. For mixed plantations the distances apart will depend upon the associated crop.

The after care of a kapok plantation requires little expenditure. The soil should be kept loose round the plants for a few months, and if kapok is the only crop, the ground need only be cleaned for a short distance around the tree to facilitate the collection of the pods, the remainder of the plantation being planted with a cover crop to reduce weeding to a minimum.

HARVESTING

The pods ripen during the dry season and should be collected each day as they fall to the ground; but when rains are likely to occur they should be picked from the tree as they mature to prevent the floss from being damaged. The pods can be picked at the time their colour changes from a light green to a light brown, when their surface becomes slightly wrinkled and before they are open at the end. They can only be gathered from high trees by means of hooks or knives attached to long poles; the branches are too brittle for the trees to be climbed. The collected pods are spread out on a dry floor to ripen thoroughly in the sun and the floss is removed as soon as possible.

The process of opening the pods and removing the floss and seeds is always done by hand, chiefly by women and children. If masks and goggles are not worn the very fine fibres may cause irritation to the eyes and throat, which has in some places caused the cultivation of kapok to be abandoned.

The most important process is the separation of the floss from the seeds. A native method is to place a quantity of floss on a perforated platform and beat it with bamboo sticks wielded in a horizontal direction so that the seeds are loosened and fall through the holes; the top layer is removed to another platform and given another beating when it is ready for baling. On a large scale machine-cleaning is essential. The Bley machine, invented by a Java planter, is claimed to be able to clean 217 kilos of floss per hour; a smaller machine of British manufacture can clean 120-130 kilos of floss per day of ten hours.

Kapok should be graded carefully before baling for export; there are four

grades of cleaned Java kapok recognized:—

1. Superior, containing less than .5 per cent of seed.
2. Prime, containing not more than 2 per cent of seed.
3. Fair average, with not more than $3\frac{1}{2}$ per cent of seed.
4. Damaged.

BY-PRODUCTS

The seeds, which contain an oil similar in properties to that of cotton seed, are sold mainly at Rotterdam. The oil after refining is edible and is suitable for soap making and other purposes to which cotton seed oil is applied. The residual meal is of low value and is used principally as an ingredient in compound feeding cakes.

The tree has been suggested as suitable for the manufacture of pulp or paper. It grows rapidly and yields a soft wood producing a brownish yellow pulp, which, when bleached, will furnish a paper of an ordinary quality.

In India a poor reddish fibre is sometimes prepared from the bark which is used locally for making ropes and papers. The wood is also used there for tanning leather.

An almost opaque dark red gum is obtained from the tree in India and Ceylon. It is astringent and is said to be employed medicinally. The young leaves and roots are used in native medicine.

KAPOK SUBSTITUTES

Flosses allied to that of kapok, *Ceiba pentandra*, are yielded by other members of the *Bombacaceae*, among them *Bom-
bax*, *Ceiba* and *Chorisia* spp. of South America, *Eriodendron samauma* of Brazil and *Ochroma lagopus* of tropical America and the West Indies.

Floss from *Bom-
bax malabaricum*, the Indian kapok, when properly prepared

is of good quality but not so resilient as kapok from *Ceiba pentandra*. Other species of the genus, especially *B. buinopozense*, occur in West Africa, where their floss is used locally. The possibilities of the Tanganyika *Bom-
bax*, *B. rhodogynaphalon*, and others might be worth investigating.

Other plants that produce flosses are *Asclepias* spp., *Calotropis gigantea*, *C. procera* and *Gomphocarpus brasiliensis* in the *Asclepiadaceae*, *Cochlosperum Gossypium* of the *Cochlospermaceæ* and *Funtumia elastica* and other genera in the *Apocynaceæ*. All of these flosses are inferior to true kapok and are not likely to compete with it in the European markets.

II—KAPOK IN TANGANYIKA

By T. H. MARSHALL, Agricultural Officer,
Department of Agriculture, Tanganyika Territory.

The main producing areas of kapok in Tanganyika are the Tanga and Eastern Provinces. In the Tanga Province it is estimated that there are some 5,000 acres under the crop and in the Eastern Province about half this acreage. In a number of instances the trees are planted as boundaries of estates, at roadsides and in similar situations, but with the planting development which has taken place during recent years, kapok has been more generally planted as a pure crop.

There is considerable divergence of opinion as to the best or most economic planting distance at which the trees should be spaced, and on one fairly large estate experiments are being made to determine which spacing is best. The experimental planting distances range from four to eight metres (thirteen to twenty-six feet) and results clearly indicate that a spacing of eight metres or even more is to be preferred. Even at this distance, the long lateral branches grow into those

of adjoining trees. It should be noted that the spacings referred to above are on land eminently suited to the growth of kapok and in poorer soil perhaps a closer spacing would be suitable.

In order to facilitate the picking of the fruits, a few plantations have tried a system of topping or cutting back the leading shoots when the trees have reached a convenient height; but after a time new leading shoots and suckers generally appear which must be periodically removed, an expense which it is doubtful if the practice warrants.

Two varieties of the tree are recognized by planters in the Eastern Province of Tanganyika, one variety bearing larger pods than the other. That with larger pods is probably the "Togo Edel-kapok" referred to in Section I. Observations on the yields from these varieties go to show that a well-grown tree of the small-podded kind will yield about three kilos of floss a year. A tree of the large-podded kind may give as much as five kilos, but this variety tends to bear such a crop only every other year.

Except in the young stage, but little attention in the way of cultivation is given to the trees, and what methods are adopted are for ease of gathering the crop, namely slashing weeds and the prevention of fire in the plantations.

Harvesting is done as outlined in Section I. Floss that is clean and collected from ripe fruits gives a first grade product, but when the pods are picked green and ripened in the sun a second grade quality is the result. The preference shown in the market for Java kapok appears to rest principally on its established reputation for purity, quality and cleanliness. The floss from Tanganyika is equal to that of Java.

There is no standard size of bale or weight of bale for export from the Ter-

ritory. In the Eastern Province one of the principal shippers presses the bales to an average of 253 lb. gross and to 16 cubic feet. Bales *may* be pressed to 375 lb., but this means re-pressing, and reports from brokers show that the fibre, when submitted to such pressure, is useless for such purposes as lifebelts, as the buoyancy of the fibre is destroyed.

Exports and values of kapok from the Territory during the last four years were as follows:—

Year	Cwt.	Value
1934	2,186	6,263
1935	2,492	4,695
1936	2,959	5,575
1937	3,100	6,302

These figures do not however represent the total production as kapok is used locally for a number of purposes.

III—PESTS AND DISEASES OF KAPOK

By W. VICTOR HARRIS, M.Sc., F.R.E.S.,
F.Z.S., Entomologist, Department of
Agriculture, Tanganyika Territory.

Kapok in Tanganyika is comparatively free from serious pests and diseases. In fact to date the only major pest to be observed is the mealy bug *Phenacoccus iceryoides* Green. This mealy bug, which also occurs spasmodically on cotton, can breed up in considerable numbers, and if permitted to spread throughout the plantation causes much damage to mature trees as a result of leaf shedding and die-back. In nurseries *Helopeltis* bug, *Helopeltis bergrothi* Reut., may cause malformation of young plants and seriously retard their development. Foliage is on occasion attacked by flea beetles and hard-back beetles, but they are only

dangerous when the trees are young. A long-horned beetle, *Diastocera reticulata* Thomp., ring-barks young trees and causes their death; it is normally found on wild acacias. The larvae of a long-horned beetle bore into mature trunks and branches and cause copious gumming, which though unsightly has not yet been observed to result in serious injury. The caterpillars of a large Cossid moth also bore just beneath the bark of large trees. They construct tunnels of frass and silk on the surface of the trunk. Injury results when these caterpillars ring-bark branches.

No pests of green-pods are recorded here. Cotton stainers of the genus *Dysdercus* are found on kapok trees but do not appear to induce staining of the fibres as with cotton. Opened pods remaining on the tree are frequently found to contain pink caterpillars, but these are of no economic significance.

The question of the relation of kapok cultivation to cotton pests in Tanganyika has been investigated and there is no evidence to show that it has any significant effect. Kapok grown as a plantation crop has a limited harvesting season, and does not act as an important host plant for those species of cotton stainers which are of importance here.

In other countries a variety of pests are recorded, most of which are of similar type to those listed above. A caterpillar, *Mudaria variabilis*, feeds in young pods in Java, destroying the seeds and

spoiling the fibres. Boring beetles of the genera *Plocaederus* and *Batocera* are of importance in the East Indies; and one, *Batocera rubra* has been a major pest in Mauritius. A twig-girdling weevil, *Alcides leeuweni* is an important pest in Java.

Kapok growing has been discontinued in the West Indies where it is an alternative host for cotton stainers, and in parts of West Africa and the Congo it has been cut out owing to it being an alternative host of the cacao bug, *Sahlbergella singularis*.

Bats, rodents and monkeys sometimes do a considerable amount of damage by eating the green pods and growing shoots. Squirrels are a particular nuisance in this respect.

Both in East Africa and the East Indies, parasitic flowering plants of the genus *Loranthus* are among the worst enemies of kapok. These parasites are spread by birds and are usually to be found on the uppermost branches. They send suckers into the tree and, absorbing the nutriment necessary for the growing shoots, weaken and kill off the kapok. This can be prevented by inspecting the plantation at frequent intervals and cutting out infested branches.

Diseases are of relatively little importance. A leaf spot caused by *Ramularia eriodendri*, a root disease due to *Ustulina zonata*, and "pink disease", *Corticium salmonicolor*, are recorded.

Virus Diseases of East African Plants

VII—A FIELD EXPERIMENT IN THE TRANSMISSION OF CASSAVA MOSAIC

By H. H. STOREY, M.A., Ph.D., and R. F. W. NICHOLS, *East African Agricultural Research Station, Amani.*

General field observations indicate that there may be seasonal differences in the rate of spread of the mosaic disease of cassava. It may be surmised that the age of the plant at the time that it becomes exposed to infection may influence its susceptibility. This paper describes an experiment in which these two points have been tested.

The Experiment.

The experiment was started in March, 1934, on land provided by the School of the Universities Mission to Central Africa at Kiwanda near Amani. Thanks are due to Canon Hellier and his staff, both for placing the land at our disposal and for maintenance of the experimental area.

Forty-eight square plots, each of nine plants, were laid out. Around each plot a hedge of mosaic-diseased cassava was planted some months before the experiment proper began. In consequence, every experimental plant was adjacent to a diseased one, except only the one plant in the centre of each plot. This is a very necessary precaution in experiments of this kind; there is much evidence that nearness to a diseased plant has a great influence on the probability of infection. The lay out was intended to ensure that all the experimental plants were exposed to a high and nearly equal infection-rate.

In each plot one healthy cassava plant was established at the beginning of each month during two years. The position within the plot was chosen from all the vacant positions by drawing a card. To

avoid error through the accidental failure of cuttings to root, two were planted together in each hole and one of these removed when growth had started.

The healthy material was all of the variety Mbarika. For most plantings the material was from a clone, raised from one original cutting but on seven occasions this supply failed and selected cuttings from a plot of Mbarika were used.

Records were taken at the beginning of each month, and all plants that had contracted mosaic were then removed. After eight months from planting, all surviving healthy plants, being now mature, were also removed. Thus, assuming that no infection had occurred, each plot, once the experiment was under way, would have contained at any time eight plants, one one month old, one two months old, and so on to one eight months old. In fact however the majority of the plants succumbed in a short time to the disease and so were eliminated.

The Climate of the Site.

Kiwanda lies at an altitude of about 550 feet, in a valley near the eastern foot of the East Usambara Mountains, distant about five miles from Amani direct. No meteorological records are available, but the rainfall-distribution may be inferred from records maintained at Tongwe Mission, four miles to the south. Here the mean monthly records over seven years show a fairly evenly distributed rainfall throughout the year, rising to a peak in May and falling to minima in January and July. No monthly mean falls below

2.3 inches. Individual months through the period of the experiment however returned lower figures than this, in particular, January, 1935, with .02 inches. Except in this one month, when all new planting died, rainfall was enough in every month to allow the cassava cuttings to establish themselves with the assistance of a single hand-watering at planting during the driest. The mean annual rainfall at Tongwe is 68 inches, but at Kiwanda is probably somewhat higher.

Although no temperature records exist for Kiwanda the conditions may be inferred from general knowledge of the Usambara climate¹: mean monthly maximum of 33°C. during the hottest month (February or March) and a mean monthly minimum of 19° for the coldest month (July or August). These conditions are typical for the Usambara foothills wherever a similar rainfall regime holds.

Results.

The results of most practical significance are brought out in Figure 1. The graphs here show the increase in the percentage of infected plants in the plantings made at the beginning of each month throughout the two years. There is close agreement between the results of the two years. Planting made at the beginning of June survived largely uninfected for the longest time; that is, throughout the greater part of their growing-period they tended to remain unhandicapped by the ill-effects of the disease. To a lesser degree, May, July and August were favourable planting months. On the other hand, all plantings from December to April were largely diseased after three months' growth.

It will be noted however that at the end of eight months' growth almost all plantings were entirely diseased. May

and June alone show a substantial proportion of survivals. Even in these plantings well over 50 per cent of the plants became diseased. Under the conditions of the experiment the chance of a plant remaining healthy during an eight-month growing-period is slender, whenever it be planted.

A statistical analysis of the figures fails to show that the susceptibility of the plant varies with its age during the period of normal growth. Owing to the manner in which the experiment was performed, it was possible to compare the infections recorded, during each month of the year, in plants of all the several age-classes. During their second month of growth from planting, the infections recorded were probably significantly less than during any other month. We interpret this, not as indicating an enhanced resistance at this age, but to a lessened risk of receiving a dose of the virus. For to produce visible symptoms the virus must have been inoculated into the plant about a fortnight earlier. Thus infections recorded during the second month of growth were the result of inoculations received between half-way through the first month and half-way through the second. But at one fortnight from planting the cuttings had barely started to produce shoots; so that we cannot say that these plants were fairly exposed to infection for the full period of a month.

In plants over two months old, the records show no significant relation between age and the probability of the plants becoming infected. The results have been analysed month by month; for twenty of the twenty-four monthly recordings the deviations from expectation in the several age-classes are certainly no larger than might be encountered by chance. For four monthly recordings the

¹See Moreau, R. E., *Journ. Ecol.*, vol. 23, p. 8.

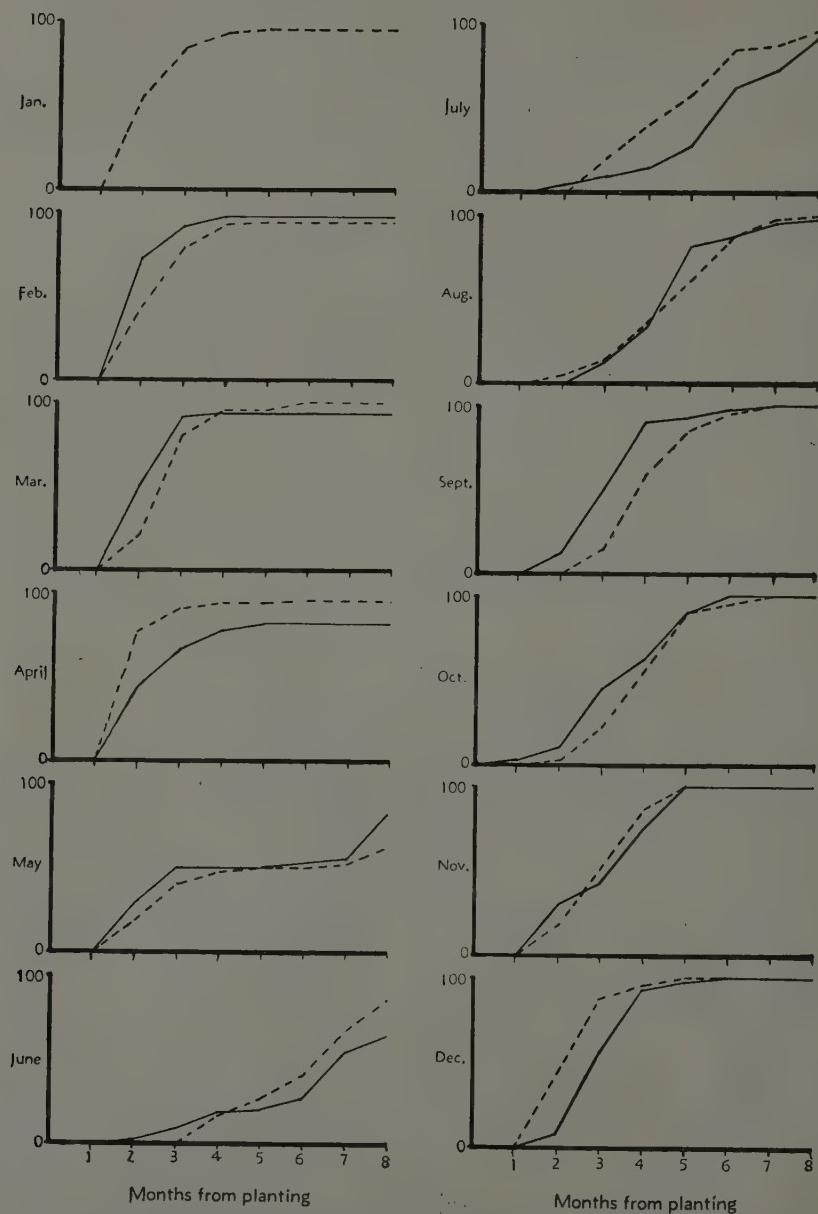


FIG. 1.—Mosaic disease in Cassava. The percentage of diseased plants at the end of each month's growth, in plantings made at the beginning of each month throughout two years—1934-35 and 1935-36.

deviations are significant; the reason for this is not evident, but the figures here give no indication that one age-class is consistently more susceptible than another.

The mean probability of infection appearing in all age-classes (except two months) shows a large variation with season. The mean probabilities for each month of the year appear in Figure 2. The probabilities are high during February to May, the highest figure being .81

for March; that is, during this month about 81 per cent of all the plants exposed under the conditions of the experiment may be expected to succumb to the disease. On the other hand after May the probabilities fall off rapidly and remain at a low value during August to October. This again emphasizes the advantage of June planting; the plants then pass the main period of their growth during the months when infection is at its lowest ebb.

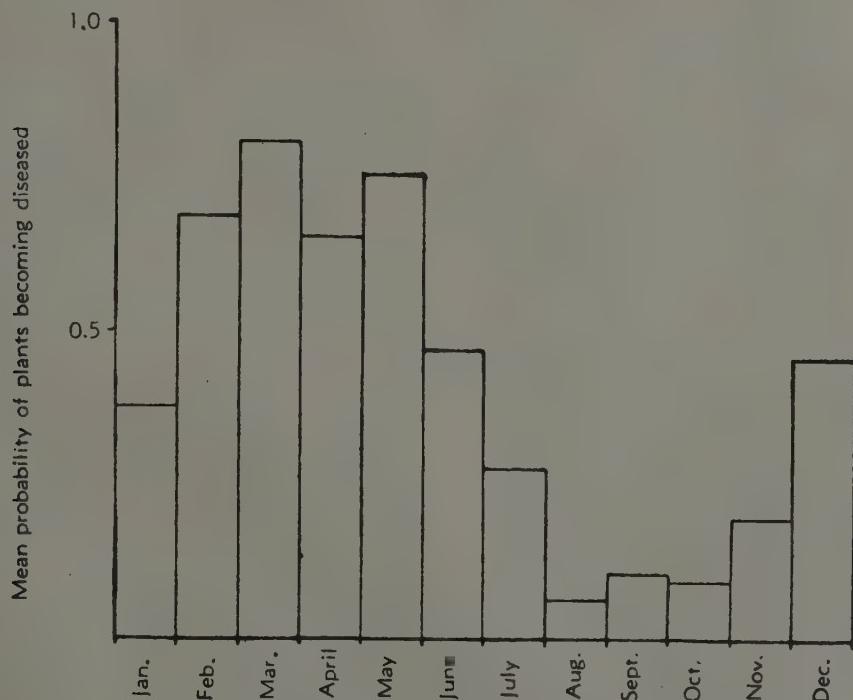


FIG. 2.—Mosaic disease in Cassava. The mean probability of the disease appearing during the months of the year in plants of all ages between two and eight months.

An Agricultural Survey in Buganda

By N. S. HAIG, B.Sc. Agric. (Lond.) Dip. Agric. (Wye), Senior Agricultural Officer,
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Surveys of small administrative areas were first undertaken by members of the Agricultural Department in order to obtain a clearer idea of the farming methods employed by the natives of their own particular area. Since the formation by Government of the Agricultural Survey Committee in July, 1935, the scope of these surveys has been extended to include the study of several other aspects not previously investigated. The purpose of the Agricultural Survey Committee is to co-ordinate the facts brought to light by the various surveys and to apply such information for the framing of a policy which it is hoped may avert the progressive deterioration of agricultural land and the destruction of forests, which has occurred in other parts of Africa.

One or more surveys are now made annually by the Agricultural Officer of each district. The area surveyed is a *mutala*, which in the Luganda language means a hill, and which in Buganda Province comprises an area of one half to four or five square miles, and supports a population of 200 to 300 people.

In the present article, it is intended to give a rough outline of the kind of information collected when making one of these surveys, and a few of the conclusions which may justifiably be reached as a result of the small number of surveys already done.

It will be of interest first to give a description of the type of country and of the inhabitants met with, in the typical agricultural areas of Buganda Province.

The country itself consists of a series of rounded or flat-topped hills (*mitala*), divided by valleys which for the most

part are swamps draining into Lake Victoria, the Kafu River or Lake Kyoga, with dense masses of Papyrus as the predominant vegetation.

The surface of land occupied by these swamps is huge, and represents a potential reserve of land the bulk of which might be reclaimed as agricultural land at considerable cost should the necessity arise. The total area of uncultivable land (water, swamp, forest, etc.) in Mengo district, which is the largest district in Buganda Province, is given as 3,338,844 acres. This is 44 per cent of the total area of the district, and gives a good idea of the immense area of unutilized land. Bordering the papyrus swamps are narrow strips of forest which are being more and more encroached upon as the pressure on land increases. The sides of the hills are clothed with Elephant grass (*Pennisetum purpureum*) which gives way to various shorter species of grass at the summits of the hills (mainly *Andropogon* and *Hyparrhenia* spp.). The hill tops are largely used for grazing cattle. The above description applies more especially to the intensively cultivated Elephant grass country which extends in a strip some twenty to fifty miles from Lake Victoria.

The annual rainfall in this area is in the neighbourhood of 50 inches, and although the year may roughly be divided into wet and dry seasons, such a division is not so clearly defined as in the Eastern and Northern Provinces. Outside the Elephant grass strip, e.g. further north and west, short-grass undulating country takes its place, rainfall is lower, and the population is concentrated into small centres, the intervening country being occupied by game. Communications are

good, and a network of main roads serves the agricultural areas. In addition to the main roads, there are numerous second class roads which are in general use by lorries during the dry months of the cotton season.

On a typical hillside or *mutala* viewed from a neighbouring one, cultivation starts on the lower slopes just beyond the fringe of forest or swamp. Each homestead is surrounded by a large banana garden with bark cloth trees dotted here and there through it; the other crops, such as cotton, coffee and food crops, are cultivated farther away from the house-compound. During recent years, cotton cultivation has increased to such an extent that clearings have crept farther and farther up the hillsides, and in many places this year the whole of the top half of a hill has been cleared and planted with cotton. It is frequently maintained that soil erosion in Buganda Province has not yet commenced to any dangerous extent, and such an assertion is presumably based on the amazing recovery under rest of which the soil in most parts of the Province is capable, unless deterioration has already gone too far. A careful inspection of some of the most thickly populated areas, however, will show that this is a mistaken idea. Although there is no immediate danger of large contiguous areas of land becoming completely worked out, the sum total of the small patches of land which have been ruined by careless cultivation must amount in the aggregate to a very considerable figure.

The cotton acreage alone in Buganda Province now approaches half a million acres, and this and sweet potatoes, one of the main food crops of the Baganda, are the two most dangerous crops from the point of view of soil erosion. A good cotton crop results in comparative wealth

to the grower, and a large proportion of his money is devoted to the cultivation of a still larger acreage of cotton during the coming year, without due regard being paid to the maintenance of soil fertility. The supply of immigrant labour during recent years, with the possible exception of 1937, has been more than sufficient to fulfill the requirements of Baganda growers.

Land in Buganda Province is mainly privately owned by the Baganda. Under the Uganda Agreement in 1900, approximately half of the total area of the present province was assured in private possession to the King, his relatives and certain Chiefs. Since that time very numerous changes have taken place through inheritance and sale, the larger estates being split up and sold. At the present time, there is a growing desire on the part of tenants to possess their own land, and big estates are being more and more cut up and purchased in lots of from five to thirty acres, the price varying from Sh. 5 to Sh. 100 per acre and upwards according to its proximity to large townships. This general trend is very desirable, and it is found that the owners of these "small holdings" are much more open to advice on better farming methods than the ordinary tenant on someone else's land. It is difficult for a landlord to evict a tenant unless the latter grossly misuses the land. Some mention should be made here of the liabilities of a tenant. His obligations to the landlord are:—

- (a) the payment of *Busulu* or rent.
- (b) the payment of *Envujo* (crop tax).
- (c) certain minor obligations in respect of beer making, also a tribute on bark cloth trees.

Busulu, formerly paid in kind or by labour performed, was changed

later to an annual tax. *Envujo* dates back to a considerably earlier period than *Busulu*, and was always paid in kind. Nowadays it is assessed on the acreage under economic crops (e.g. cotton and coffee), grown by each tenant, and is a money tax. Payment of the above taxes gives a tenant the right to cultivate what crops he pleases on his holding and assures him reasonable security.

As mentioned previously, the surveys of typical *mitala* have as their main object the presentation of facts which will give a clear picture of the general trend of native farming, as practised at present, and of possible future developments. The *mitala* are so chosen as to fall into three classes:—

- (a) those in which the population is sufficiently concentrated to preclude the possibility of further increase, without causing soil deterioration.
- (b) those in which the population has already become so dense that soil deterioration has actually commenced.
- (c) those in which, whilst being fairly thickly populated, there is still room for considerable expansion without causing soil deterioration.

In Buganda Province, six surveys have so far been completed. Of these areas, one falls into the first of the three classes mentioned above (a), three into the second class (b), and two into the last (c).

For the purpose of this article, the *mitala* in class (a) will be described in some detail, but figures obtained in two other surveys in the same district will be given for the sake of comparison. The choice of this particular *mitala* has been made because it is representative of the very fertile country of Buddu in

Masaka district, and of many other parts of Buganda Province.

DESCRIPTION OF THE AREA (Kawoko *mutala*)

The area included in the survey is not the whole *mutala*, but that part of it comprised in a private native estate. It was decided to restrict the survey to these limits, as the farms in the remaining portion of the *mutala* (less than half of the whole) are very much more straggling and would therefore be unrepresentative of class (a) mentioned above. By disregarding this area only twenty-eight taxpayers were omitted. The area surveyed is bounded on the north side by a main road, on the south by the boundary of the estate and on the east and west by swamps which are branches of the Namajuzi river. The general topography of the *mutala* is similar to the short description given above, e.g. a hill surrounded by swamps of the usual Buganda type. The soil is the common red loam overlying rocks of the basement complex but becomes gravelly near the top of the hill. The natural vegetation is Elephant grass (*Pennisetum purpureum*) and short grass (mainly *Andropogon* spp.), which together cover the cultivated land. Adjoining the area along the main road is a settlement of Indian traders, known as Kawoko, which is an important local centre for both cotton and coffee buying. The nearest large township is Masaka, some fifteen miles to the south east. The land owner, who is a Mohammedan woman, usually resides in Kampala. There is a small school for Mohammedan children on the estate.

DETAILS OF ACREAGE UNDER CULTIVATION, ETC.

The total area of the estate is exactly one square mile, 640 acres, and the whole of this land is cultivable. From this area, however, it is necessary to subtract 5.63

acres for house compounds, and 3.96 acres for a second class road (known locally as a *bulungi bwensi* road) and footpaths. The total area therefore which is available for the cultivation of crops is 630 acres approximately.

There are two distinct planting seasons in Buganda Province corresponding with the two rainy periods, e.g. March to May and September to November, which may conveniently be called spring and autumn respectively. It is necessary therefore to do two separate surveys of the same *mutala* to obtain full information on the acreage under crops. During the spring survey, 297 acres were found to be under annual food crops, mainly beans, ground-nuts, sweet potatoes and maize. The acreage under these crops at the autumn survey was 85 acres. To this latter figure must be added 74 acres of coffee and 194 acres of plantains already measured at the spring survey, and also 10 acres of coffee, and 1 acre of plantains which were planted between the spring and autumn surveys, making a total of 364 acres under cultivation at the autumn survey. The increase is of course due mainly to the cotton crop, which was planted between May and September, after the spring survey. Deducting the totals of the acreage under cultivation during the spring and autumn surveys from the total area available for cultivation (630 acres) it is found that the total area under resting land at the spring survey is 333 acres, and during the autumn survey 266 acres.

DETAILS OF POPULATION

The estate is populated by 88 families, the heads of 65 of which are taxpayers. The actual number of natives in these families is 297 excluding hired labour. Details were taken of the number of adult males and females, and also the number of children, which were divided

into two classes, those capable of agricultural work and those too young. From these data a figure of 2.67 was obtained for the total labour equivalent per family, after making allowance for the number of hired porters engaged on each holding.

In assessing the number of work units per family, the following figures were utilized:—

1 man is equivalent to ..	1.00	work unit
1 man (old) is equivalent to ..	0.50	" "
1 woman is equivalent to ..	0.75	" "
1 working child is equivalent to ..	0.25	" "
1 hired porter is equivalent to ..	1.00	" "

The total number of hired porters engaged on the 88 holdings was 62. The average acreage per taxpayer and per family unit of the more important crops cultivated is shown below:—

CROP	Acreage per Taxpayer	Acreage per Family Unit
Coffee	1.15	0.74
Plantains	3.03	1.94
Sweet Potatoes ..	0.17	0.11
Cotton	1.08	0.70
Other Food Crops ..	0.27	0.17
	5.70	3.66

CULTURAL METHODS EMPLOYED

Cultivation throughout Buganda Province is entirely by hand. Only three agricultural implements are employed—the hoe, a short knife with a curved blade, and the cutlass. The hoe used by the Baganda has a short handle and usually an imported blade, though the locally-made blade may sometimes be seen. Banyaruanda generally use a longer-handled hoe. The curved knife is used by the women for cutting off and peeling plantains, and to some extent for miscellaneous agricultural purposes. The cutlass is used for general purposes such as the cutting down and splitting of plantain stems for use as a mulch.

The usual time-table of the working day is as follows. Both men and women start work in the fields almost as soon as it is light, and the women work until about ten o'clock, when they go home to prepare the mid-day meal. The men go on working until about half-past eleven, when they come home and dinner is eaten about twelve o'clock. Both men and women resume work about three o'clock when it begins to get cool; the men work in the fields up to about five o'clock, and the women are occupied with fetching water and preparing the evening meal. There are, however, many individual exceptions to this rule.

While in most cases the plots owned by each cultivator are centred round his homestead, in areas such as this where land is scarce many cultivators have also been forced to take up plots on the fringes of cultivation, which may be at some distance from the main part of their holding. Some of these plots may be so distant that a considerable amount of time is wasted in walking to them for field work. Statistics were collected of the proportion of such plots, as they give in some sense a measure of the pressure upon the land by the farming community. In this *mutala*, out of a total of 778 plots measured at the two surveys, 119 plots or 15 per cent were separated from the main holding of the owner.

ROTATIONS

Of the crops grown by the average farmer in Buganda the banana garden is permanent, as also is the coffee plot. Apart from these, all crops grown are annual ones. A properly cared-for banana garden should last up to fifty years if kept enriched and mulched with dead leaves from banana plants, and other household rubbish such as banana and sweet potato peelings. Unfortunately, the standard of cultivation of banana gardens has declined very much of late.

The coffee plot can only be called semi-permanent. Interplanting with cotton, or beans, or groundnuts is usual for the first few years at least. Much propaganda has been done to encourage the use of Elephant grass or other grasses as a mulch for coffee, but results to date are disappointing.

The common practice after clearing a piece of new land is to plant early sown cotton, e.g. in May or June. This will be harvested in January and February, and the plants uprooted and burnt in March, after which food crops will be planted, either beans or groundnuts singly or mixed, and often interplanted with a few maize plants. As soon as these are harvested, a late-sown crop of cotton is planted. Beans and groundnuts are very commonly sown between the rows of cotton, and help largely to check soil wash on hilly land, as well as providing an additional source of food. This succession of food crops followed by cotton may continue for several years, sometimes for as many as seven or eight years when land is scarce, by which time the soil has become powdery on the surface, and has lost its texture and fertility. It is all too common to find that a farmer will now plant coffee in this worn-out soil, thus giving a permanent crop the worst possible start. Cotton may even be taken as a catch crop in the young coffee for another two years.

In areas where land is still fairly abundant, the above rotation will occupy three to four years, and the land will then be rested for a similar period. When land is scarce, and cultivation has to be extended to cover six or eight years on the same plot, weed growth is encouraged to a certain point, the weeds being dug into the soil in an attempt to enrich it. Also, maize, *muhemba* (*Sorghum* spp.), and cassava are planted on the boundar-

ies of cotton plots, and more beans and groundnuts are planted between the rows of cotton.

The foregoing is the commonest form of crop rotation practised in Buganda Province, although many farmers have their variations. With regard to the other food crops, sweet potatoes are not included in the above rotation. They are planted in a separate plot, and may follow each other year after year, or may be rotated with maize or simsim, to be followed later by bananas. Sweet potatoes are not included in the above rotation. They are planted in a separate plot, and may follow each other year after year, or may be rotated with maize or simsim, to be followed later by bananas. Sweet potatoes may be planted continuously on the same plot until it has to be abandoned. Groundnuts are usually given preference as regards soil; they are frequently planted in "virgin" soil, or taken after the first crop of cotton on freshly cleared land.

A proper picture of Buganda agriculture is incomplete without the realization of the extent to which the people move about from one village to another. Probably the chief method by which soil fertility is maintained and restored is not by any system of management or rotation, but by the fact that when the cultivators find their crop yields are diminishing, they leave the village and move to another. In this way whole villages may sometimes lose the bulk of their population within a short period, while other almost uninhabited hills may suddenly become quite populous villages.

LIVE STOCK

Throughout the Elephant grass areas cattle are only kept very sparingly. On this *mutala*, three cattle only are owned by residents, but are not kept on the actual *mutala*. Poultry, sheep and goats

are kept by all families and the average number per taxpayer was found to be: poultry, 4.59; goats, 1.12; sheep, 0.20. A number of rabbits are also kept for sale by some of the residents. The keeping of live stock therefore hardly enters into the agriculture of the area, and no bad effects are caused through overgrazing by stock. It is the duty of the children to herd the sheep and goats which find plenty of rough grazing; beyond this, no special feeding is supplied, except that banana peelings mixed with a little salt are sometimes given in the evenings. Both sheep and goats are used for consumption by the owner's family rather than for sale, but a saleable goat may fetch from Sh. 6 to Sh. 30 and a sheep from Sh. 6 to Sh. 15. The dried skins may fetch up to Sh. 1 apiece.

DIET

The food of the Baganda consists almost entirely of bananas and sweet potatoes, the number of varieties of each being very numerous. There are two main classes of bananas, the *matoke* varieties which are eaten boiled and the *gonja* varieties which are roasted. The former makes up by far the greater part of the diet. The other food crops grown are merely accessory to these two main foods. Meat is looked upon as a luxury by the average *Muganda* peasant and is only eaten on special occasions. Native beer, made from a third class of banana (*Luganda mbidde*) and *Sorghum* spp., plays a large part in the diet of the Baganda. With regard to the number of meals, the common habit is to eat one at noon and one in the evening, the same foods being eaten at each meal. In some families a small meal may be eaten before starting work in the morning.

Information was also obtained on several other points affecting the life of this small agricultural community, such as the division of labour between men and

women, details about the domestic water supply, and the fuel and timber supply, also local industries, such as bark cloth making. The co-operation of the Sanitation Department made it possible to secure some very useful additional information on rural housing and sanitation.

At a meeting of the Agricultural Survey Committee held in May of this year, the surveys done to date, nineteen in number, were reviewed, and it was decided that the present method should be continued with until at least one hundred *mitala* had been studied.

Although the data so far obtained are insufficient to arrive at many definite conclusions, interesting facts have already come to light. The proportion of resting land to land under annual crops in Ka-

woko mutala is 3.1: 1. In the other two *mitala*, Kabale and Kayuji, the figures are 3.4: 1 and 2.6: 1 respectively. These figures show that the areas, though heavily populated, still have large amounts of resting land, and the present situation is not serious. In another part of Buganda Province, on the other hand, the ratio between resting land and land under annual crops falls to as low as .03: 1, and there is ample evidence that both erosion and soil deterioration have occurred to a dangerous extent.

I am indebted to Mr. G. B. Masefield, Agricultural Officer, who actually carried out the surveys of the three Masaka district *mitala*, and a large part of whose report on Kawoko *mutala* has been quoted verbatim.

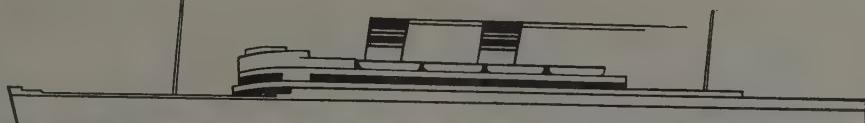
Suckling and Suckling Preference in Pigs

It is often asserted that during the suckling period each member of a litter has its own teat, i.e. sucks regularly at a particular nipple, the assertion being based on general observation. Recently, however, Dr. H. P. Donald of the Institute of Animal Genetics, University of Edinburgh, has made a series of direct observations relative to the subject, and his record of them in the *Empire Journal of Experimental Agriculture*, Vol. 20, p. 361, shows that the popular conception is a true one.

In the case of a sow that almost invariably lies on the same side for suckling—not because she lies more comfortably on that side, but in deference to the clamour of her offspring when she adopts an attitude different from the one to which they are used—and when there are more teats than little pigs, each of these almost invariably gets its correct teat or teats (for a single pig may suck both of a hinder pair). When, however, a sow insists on lying on either side as she chooses, when there are only just enough teats to go

round, or when one of the teats is unpaired, there may be a certain amount of confusion, particularly among the pigs in the middle; but this in no way invalidates the general assumption that each pig has its own teat. In fact when it is realized that the period of time during which a sow lets down her milk at each suckling is only about a minute, some arrangement by which all the pigs get to work at once is obviously necessary. They may be said to be born with the instinct to use one nipple. At the very first a preference is shown for the anterior teats, probably because of their distance from a disturbing hind leg, and the ones who get them are fortunate, because they contain the most milk. The others, however, soon become reconciled to acceptance of less favourable positions, and all then become capable of recognizing their positions in relation to the conformation of the sow as a whole, and accustomed to seeking the proper nipple in the upper or lower row as the sow changes from side to side.

H. E. H.



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Green Manuring and Composts in Plantation Crops

There is no doubt that composts are very valuable manures and in the case of cereal or mixed farming the conversion of the enormous quantities of waste matter produced in the form of straw into a valuable manure is exceedingly good farming practice. It is also now realized that in such farming green manuring is apt to be chancy. When we come to plantation crops that occupy the land continuously the picture is rather different. Green manures do benefit the crop and only when improperly used is there any deleterious effect—the term green manure is used in its widest meaning to include weed growth, prunings and leaf fall from shade trees. Among the improper usages of green manure must be included permitting grass to become dominant. The ardent protagonist of composting insists that all such materials must be composted till a carbon nitrogen ratio approximating 10:1 is approached. Some in Kenya do carefully collect all weeds, prunings, etc., and compost them with the normal wastes of a coffee plantation. Is this good farming and economical?

This subject with special reference to tea in South India was discussed by Dr. K. B. W. Jones, Assistant Tea Scientific Officer, in a lecture to the Nilgiri Planters' Association.¹ While the conclusions are not fully applicable to East African conditions, they are of interest. In South India, too, the compost enthusiasts are removing all trash for composting outside the plantation. Conditions there are very different from those in East Africa. The rainfall seems to be more evenly distributed. Tea plantations are generally well shaded, so there is ample addition

of humus-producing materials in the form of leaf fall, prunings and loppings. The Tea Research Department is definitely of the opinion that under the conditions of the Nilgiris, composting, generally, is a waste of money. Where "boosting" of an area is needed, compost made from material from cultivated areas should be used.

It is pointed out that compost is more than a source of humus, it is a very active fertilizer. Tea removes mainly phosphate and potash, under the local conditions nitrogen-fixing bacteria, utilizing the leaf fall, etc., are able to maintain the nitrogen supply. Although phosphate reserves are low in South Indian soils, in manurial experiments nitrogen invariably gives the greatest effects, there is a very little response to phosphate and potash. The application of compost, supplying readily available nitrogen, will cause an increase in the crop, definitely undesirable in these days of crop restriction. Suggestions, too, had been advanced that the application of composts improves the quality of tea, but there was no real evidence in support.

Again, when leaf fall and other trash is allowed to decompose *in situ*, there is a steady small supply of nutrients provided. The insistence that it is essential that an organic manure must have a carbon-nitrogen ratio closely approximating 10:1 before there is available nitrogen produced does not appear to be justified under humid tropical conditions. In a series of nitrification experiments conducted at the Scott Agricultural Laboratories, it was observed that nitrification was very rapid when the carbon-nitrogen ratio was 13:1. It is easily possible for the lower zone of a layer of trash to have

¹Jones, K. B. W. 1937: "Composts and Tea". *Planters' Chron.* pp. 149-154, reprinted in *Nyasaland Tea Assoc. Quarterly Journ.*, July, 1937, pp. 9-15.

such a ratio. If the trash is removed from the plantation for composting outside this steady supply of available nutrients is cut off, and a deficiency is caused.

When the prepared compost is applied, perhaps at a rate greater than supplied by the normal leaf fall, there is a sudden increase in the supply of available nutrients, causing a rapid flush.

It is suggested that, if humus is needed, it would be more economical to apply jungle trash in a green state and thus of low carbon: nitrogen ratio to supplement green manure and weed growth rather than to compost it. The nutrient supply, especially that of nitrogen, would be more regular and there would be no sudden flushes. A preference is also expressed for artificials over composts since the quantities of nutrients supplied can be carefully regulated.

How far can these points be applied to coffee in East Africa? The reviewer is certainly opposed to the meticulous removal of weed growth and trash from plantations for the production of compost. In the cooler, more humid areas, a certain amount of shading is practised. Decomposition of the trash layer does occur and as long as the soil is moist there is a steady supply of available nutrients. True, this practice does tend to produce an accumulation of roots at the surface, but this is not so deleterious as it may appear. Coffee has also a deep root system, which is able to utilize the nutrients, mainly nitrates, that have been leached down to the lower soil zones. In

the drier areas, where the effects of drought are more marked, the system of composting *in situ*, evolved by Mr. Poppleton, should be followed. Weeds, green manures and trash are buried in ridges between the rows of coffee—only do not use woody material, it is better on the surface where it acts as a light mulch. The effects of this system are highly beneficial, and the ridges running in two directions assist in erosion control.

Lest it appear that the reviewer is opposed to the use of compost, he must state that, on the contrary, he has always been a most ardent promoter of composting. The above has been an attempt to show that rational green manuring is beneficial and that the removal of green manures and trash from a plantation for composting is unnecessary. As far as tea is concerned, in these days of restriction the use of compost at once causes a flush of growth and thus an increase of crop. With coffee we are concerned with a fruit crop and not only is the effect of manuring not so quickly reflected in the crop but the manurial demands are greater. Anyone reading the original article should bear this in mind. Rational composting, in which the waste products of coffee growing together with material from uncultivated or uncultivable land are converted into manure, is an exceedingly good practice. Not only does it give a supply of available nitrogen, but phosphate can be presented to the plant in a form that does not rapidly become unavailable.

V. A. B.

The Stimulation of Root Production in Cuttings by Synthetic Growth Promoting Substances

The extraction of pure plant hormones from the plant during recent years, and their identification with certain chemicals that can be synthesized in the laboratory, has stimulated the attack on problems connected with the growth and rooting of the plant. The synthetic hormone had been found to be as effective as the natural product. While the production of certain growth reactions in the stem of a plant appeals only to the more academic research worker, the stimulation of rooting has an immediate practical appeal to the planter. By the application of these chemical substances to plant cuttings it ought to be possible to root them more quickly and easily than by any known horticultural practice. Workers in the Boyce Thompson Institute and elsewhere showed that plant tissues responded readily to these chemicals and roots could be easily stimulated to grow on cuttings of many plants. These experiments were carried out under strictly controlled conditions, normally not obtainable by the horticulturist. The test of the value of these root-promoting chemicals to horticulture therefore depends on the large-scale trials of the horticulturist, who must have a greatly increased percentage of successes before he can scrap old methods for new. Rooting of cuttings by the new methods has been attempted for a short time only and so far no definite information is available as to which is the best chemical to use and what concentration of it should be applied to the cutting.

The most commonly used of the known synthetic chemical growth promoting substances are beta-indole-acetic acid, alpha-naphthalene-acetic acid, indolebutyric acid, phenyl-acetic acid, indole-

propionic acid. These chemicals may be obtained as crystalline powders and in this form are more easily used by the research worker. Dilute solutions of the chemicals deteriorate very rapidly on standing and care must be taken to see that the solutions are freshly prepared before use.

Several proprietary preparations have been put on the market, which contain a fairly concentrated solution of one or other of the better known synthetic growth promoting substances. The biological standardization of these preparations will present difficulties as so many chemicals are known which produce similar results though in differing concentrations.

Because of the conflicting reports of the value of these chemicals in horticultural practice a meeting of interested botanists, horticulturists and chemists was held at Kew during November, 1937, to discuss the present state of knowledge on the subject, when the results from root stimulating work already obtained were discussed.

At this meeting, Dr. Tincker of Wisley pointed out that when he used plants, mostly of hardy species, that could be arbitrarily classed into three groups: (1) those rooting easily, (2) those offering medium difficulty to propagate, and (3) those very difficult to propagate, the gain in horticultural practice when using the stimulants lay in the second group. The trials had been conducted to test the acceleration of rooting, the increased numbers of roots produced and the increased percentage of cuttings rooted. Of this second group of plants 66 per cent responded to treatment. The treat-

ment of plants in group (1), which already root easily, is of no special advantage. In group (3) or those very difficult to propagate, only 8 per cent responded to treatment. Here only special knowledge of the plant and of the best time of year at which cuttings should be taken will produce results of value.

At East Malling Research Station, Kent, considerable ranges of concentration of the synthetic growth promoting substance and the times of treatment are being tested on stem cuttings of fruit-tree root-stocks. With soft-wood cuttings of plum and pear root-stocks marked stimulation of rooting has been obtained after treatment with indole-butyric acid and alpha-naphthalene-acetic acid. With treated hardwood cuttings of certain plum root stocks in the 1936-37 season no improvement in rooting was obtained, compared with untreated cuttings.

At Kew, tests have been carried out on a wide range of plants under conditions closely resembling normal horticultural practice, the work being entrusted to those who normally carry out propagation. The results obtained were variable; in some cases the treatment was beneficial, in some of no effect, while in others, untreated cuttings rooted better than treated ones.

At the Royal Botanic Garden, Edinburgh, experiments have been made with some soft-wooded tropical species. In these, treatment increases the number of roots per cutting although untreated cuttings produce roots with equal rapidity. Similar results were obtained with a number of temperate, hardy, soft-wooded species.

One experiment carried out with proprietary preparations enabled Mr. Freeman of Knap Hill Nursery Co. to classify his results as follows, according to the type of wood and bark in the cutting:

Group 1.—Those cuttings having a soft bark, inclined to be "flaky", which after treatment parts from the wood of the cutting as wallpaper leaves the wall when dampness gets behind it. This group reacted poorly to stimulation.

Group 2.—Cuttings with wood of a rather similar pliable nature but slightly stronger. Reaction was much better, and plants in this class that are difficult to root showed a 60 per cent improvement in rooting response after treatment.

Group 3.—Moderately hard-wood species in which the response was very marked.

Group 4.—Hard-wooded species, chiefly evergreens, which included the holly family. Response in this group was good, results being obtained in six to eight weeks instead of one to two years.

The problem of propagation is further complicated by the fact that in certain plants such as conifers and in certain angiosperms, e.g. *Coffea arabica*, the branches are dorsiventral, so that if a cutting is taken from a branch the resulting plants will continue to grow as branches and no leader will be formed. The only method of securing good plants from coffee cuttings is therefore to ensure that only "leader" cuttings are used for treatment. In normal angiosperms, where the branches are not dorsiventral, symmetrical plants can be obtained from branch cuttings. The type of cutting used will depend largely on the purpose for which it is required, but the selection of cuttings at the right time for propagation depends almost entirely on the skill of the operator. On this a great deal of the success of the treatment depends. In one experiment it was found that the cuttings responded more readily to treatment at certain periods of the year. This applied especially to hard-wood cuttings that were difficult to root.

It is generally agreed that leafy cuttings produce the best results and that rooting response with leafless cuttings is exceptional. The leaves increase the

amount of chemical solution absorbed by means of their power of transpiration.

Ripe lateral shoots taken off with a heel, in autumn or winter, are most commonly used.

Most workers use pure sand as a rooting medium, though some have added peat or coconut fibre. The acidity of the medium has much to do with obtaining good results. Professor Stoughton of Reading University has carried out a series of experiments with carnation cuttings, to test the influence of the acidity of the medium and the presence of nutrient materials on the effectiveness of treatment. He found that if he acidified the medium with sulphuric acid (pH 4.5), less loss from damping-off occurred than in neutral sand, while the effectiveness of the treatment was not substantially altered. If, however, acetic acid also of pH 4.5 was used to acidify the medium, the percentage of cuttings rooted in the acid medium was below that of the neutral controls, but these plants showed more roots each than the untreated control plants in the acid medium. The addition of nutrient solution to the medium produced no effect on rooting or the establishment of the cuttings.

It must be pointed out that these results apply to carnation cuttings only and as yet cannot be regarded as generally applicable. A neutral medium is usually the most effective in root stimulation work.

TREATMENT

It is agreed that at the present state of our knowledge bottom heat in the propagating frame is necessary, since only a very few plants will respond to treatment and take root in cold frames.

The most common method of treatment appears to be to stand cuttings for various periods of time in stimulant solutions of different concentrations,

afterwards rinsing them with water and transferring them to the propagating frame. The length of time they are allowed to stand in the solution varies between five and twenty-four hours, or longer if extremely weak solutions are used. The time depends largely on the views of the experimenter.

A second method is to water the cuttings with a solution of the chemical after they have been put in the propagating frame. By this method there is no pre-treatment of cuttings before placing in the propagating frame. The general opinion seems to be that this is not very successful although one man reports good results from it.

A third method is the application of the chemical to the plant in the form of a lanolin paste, prepared by mixing the chemical in lanolin and smearing it on the part to be treated. High concentrations of chemical are needed to obtain good results with this method, e.g. 25-100 milligrams of indole-propionic acid to 1 gram of lanolin. A concentration of 1 in 2,000 beta-indole-acetic acid has been stated by one worker to give good results. This method appears to be more useful in grafting as a smear round the edges of the graft, promoting rapid cell proliferation.

There are said to be no deleterious after-effects of treatment with these chemicals. The opposite is more likely to occur. Some horticulturists say that under similar conditions certain species of treated plants are much larger and stronger than the untreated ones.

If, however, the concentration of the chemical is too strong the cuttings will not root and will generally show a burnt or dead appearance. Extremely low concentrations of the chemicals must be used. For ordinary purposes 1 part in 10,000 parts of water is the strongest

solution that can be used with safety, concentrations of 1 part in 20,000 or 40,000 often show better results, while 1 part in 100,000 is excellent for many plants.

The response to treatment varies according to the concentration of the synthetic growth promoting substance used and to the time of treatment of each variety before being transferred to the

propagating medium. The physiological condition of the cuttings is apparently another factor in the response to stimulation.

The above concentrations of pure synthetic growth promoting substance are not to be taken as fixed for every plant and only by experiment can the best concentration of the chemical be determined.

J. G.

A Simple Method of Tanning Skins

The following simple method of tanning skins with chopped wattle bark may be of interest to those who live in areas in which black wattle is grown. It has been tried in the Kigezi district of Uganda, an area in which black wattle is extensively planted and the natives are largely skin-wearers. I can claim no originality in the method, the details of which reached me very indirectly. They were obtained by the Provincial Administration from the Uganda Veterinary Department, who in turn had obtained them from a member of the Kenya Department of Agriculture. To the latter, whose identity I do not know, I am accordingly much indebted. He stated that the method is one which is used by natives in Basutoland but which he had never tried himself. It is believed therefore that this is the first time the method has been practised in East Africa.

Details of the method were given as follows:—

FOR TANNING GOATSKINS

Clean the skins thoroughly.

To remove hair.—Fold the skins in two with hair outside, placing a little dry grass in between the flesh sides. Place in fresh manure and after two days examine daily to find out when the hair is ready to slip; then remove, wash, pull the hair or scrape off gently with a wooden scraper.

Tanning.—Put 2 inches of finely chopped wattle bark, green or dry, in the

bottom of a barrel, put some bark between a folded skin to keep the folded parts from sticking together, and lay on the bark. Place alternate layers of bark and skins until three quarters full. Add rain water or soft water until nearly full, stir daily with a pole. Once a week remove, hang skins in the shade until nearly dry and replace in a fresh lot of bark. Once a week in addition, the skins should be taken out, brayed (twisted), rubbed and turned. At the end of about three weeks the skins will probably be ready. A cut into the edge of a skin will show whether the tanning has penetrated. When this happens the skins should be stretched gently and dried. When nearly dry they must be rubbed and twisted with the hands until dry, to make them soft.

The method was tried on an experimental farm in Kigezi District at an altitude of 7,000 feet, and worked very satisfactorily. An old cement drum serves instead of a barrel. Under these conditions four days in the manure proved best for loosening the hair thoroughly. Three weeks was enough for the tanning process. The method was also tried on sheepskins, which seem to tan as well as goatskins. The only slight drawback to the method is that it leaves the skins with a faint purplish colour, which might be a disadvantage if it was desired to apply dyes.

G. B. M.

Tung in the Trans Nzoia

By H. BRIAN BATES, *Longleat Estate Ltd., Kitale, Kenya Colony*

Some years ago it occurred to us that an attempt might be made with Tung—the source of the well-known Chinese Wood Oil—as a third string to our coffee and maize plantation. Both my partner and I were then resident in China and recognized the value of the culture if it could be grown successfully on our farm. Feeling that anything short of a considerable acreage was a waste of valuable time, we ordered two tons of the Tung "apples" from the chief producing province in China. This was before the Chinese Government prohibited the export of Tung seed, and we had at the back of our minds even then that one day the Chinese Government would impose such a prohibition. On receipt of the apples in Shanghai, they were carefully gone over for wasters, ill-formed apples, etc., and the balance was shipped to Longleat in 1930.

We had unfortunately no planting data to go on beyond the Florida information, as in China at that time Tung was not a plantation product. It was grown by individual farmers who each had a few odd trees round their farms on land not suitable for their main crops, and delivered their tung to the nearest village possessing a primitive oil press. We therefore planted at 25 feet by 25 feet, which we now feel to have been our first mistake, as from the growth of our trees, a spacing of 10 feet by 10 feet would have been much wiser.

We instructed our manager to plant 50 acres at stake, three seeds in a hole, and to thoroughly fence the field, as all the authorities emphasized the necessity for protection against buck and hares. A three-strand fence about 4 feet high was put round with a 2-foot rabbit-wire bot-

tom. A commentary on its futility is that the surest find for a buck on our farm at any time has always been *inside* the Tung plantation fence.

A crop of maize was grown in the lines in later years, but for the first year or two the land was kept clean. This we now know to have been another mistake, as the Tung seedlings were too obvious to hungry buck. Practically every tree shows signs to-day of having been "headed" by the duiker and used as a rubbing post by the larger buck.

When we visited our farm in 1933 in October, we were rather surprised to find nothing but bare trees about 4 feet high on the average and wondered whether they were all dead. Closer examination showed that the trees were wintering and before we left the farm in November, they had all blossomed (the flowers precede the leaves) and new growth was being made vigorously. In order to conserve the strength of the trees and because we had at that time no means of pressing oil, we gave instructions for the blossom to be stripped.

Several of our neighbours bought some of our original consignment of seed and we have since been privileged to examine their plantations. We have to regretfully admit that they are usually better than our own, notably that of Mr. Oswald Bentley, which has obviously been carefully maintained since planting. Our neighbour, Mr. Pitchford, planted some ten acres and immediately grew maize on the same ground. His Tung trees look well, the maize having drawn them up; and as his farm is always maintained in perfect order, his Tung plantation reflects this and the trees are a good colour and are making good growth.

One point, however, seems common to all of us, and that is the extreme variation in the size of trees.* We can give no satisfactory explanation for this though we feel that the buck are probably responsible. It has been suggested that some seeds planted too deeply have left their cotyledons in the ground, thus getting a delayed start against shallow planted seeds. A Tung seed is fairly large and heavy and, from examinations made in our nursery, germination begins by a shoot being sent out, at the end of which roots appear. When the roots are strong enough they force the shoot (which eventually becomes the stem of the seedling) through the surface of the ground in a sort of half bow, and it then tries to lift the seed above the surface. If the ground is soft all is well, and two delicate leaves break out. If the ground is too hard, or the seed has been planted too deeply, the shoot breaks under the lifting strain.

We therefore recommend that the segment of the Tung apple, containing one nut, be planted only thumb deep, covered with leaves or chopped grass and the bed kept reasonably moist. Germination may take as long as four months, which seems reasonable when one considers that the trees in their native province in China drop their fruit about October, and it no doubt lies dormant in its protecting husk until the following spring rains.

After seeing the satisfactory progress made with the first fifty acres, we ordered a further lot of seed from China, but this was unfortunately sent in error in the nut, and not in the apple. Germination was considerably poorer than that of the first shipment but enough seedlings were raised to enable us to plant a further fifty odd acres. This second area has,

due to causes beyond our control, suffered considerably from neglect, but in spite of the fact that the seedlings are growing in thick grass and couch, very few misses are apparent and vigorous growth is being made.

We are personally convinced that Tung (*Aleurites fordii*) will grow and produce satisfactory oil nuts in this district. In 1936 only some 450 lb. of "apples" were harvested, but this year practically every tree, however small, has been laden. We cannot state at present the total weight of this year's crop of "apples", as many are still on the trees, but we estimate that it will be four or five times as heavy as last year's.

We have brought a small home-made oil press from China and hope next year, if production permits, to make an initial pressing, as we feel sure that there will be a local demand for the resulting oil, which is an excellent preparation for wood, as well as a waterproofing for fabrics. This year practically all our output has been booked for seed orders.

Should the foregoing homely remarks on Tung culture in Kenya have stimulated interest, scientific and economic data can be obtained from the following publications:—

Bulletin No. 7, Forest Dept., Kenya, 3rd March, 1932.

H.M. Stationery Office, E.M.B. 31: "The Production of Tung Oil in the Empire".

Union of South Africa Bulletin No. 140: "Tung Nut Growing".

Florida Agricultural Experimental Station, Bulletins Nos. 171 and 221.

The Far Eastern Review of November, 1936: "Tung Oil and its Trade Development in China".

Oil and Colour Trades Journal of 22nd April, 1932: "Cultivation of Tung Trees in the British Empire".

*This variation in growth is a well-known phenomenon in Tung oil plantations and is usually considered to be due to genetical differences.—C. M.

The Vegetable Garden on the Coast*

By W. SIBLEY-WARNE, Agricultural Assistant, Department of Agriculture,
Tanganyika Territory.

Considerable difficulty is usually experienced in coastal areas in establishing a vegetable garden which will produce a fair supply of vegetables and green food-stuffs during the year, and though the cultural directions herein are reliable in that they are based on coastal experience and observation, they will not apply in every detail to the higher, colder hinterland.

There are two planting periods:—

(1) October, November and December on light soil away from swamps and rivers.

(2) May, June and July in low heavy land where, if possible, the transplants can follow receding flood water. On this type of land considerably less water is required throughout the growing period.

By eliminating certain crops, such as cauliflower, rhubarb, asparagus, peas and beans which, after seven years' trial, have not been a success, and by introducing some of the Native and Indian vegetables, one is able to have a fairly good variety. Cluster beans take the place of the usual French and dwarf varieties and are found to be an excellent substitute. Vegetable marrows and cucumbers have also been left out, but these can be replaced by the native *mamung'unya* and *matango ya Nyasa* or ordinary *matango*. A marrow, "White Custard", and cucumber, "Early Fortune", have been produced by the writer but the results were disappointing. They are not suitable to low elevations in the tropics. Some of the local pumpkins equal the "Boer" or "Jumbo" variety

and are not so susceptible to fruit fly. (The same applies to some varieties of watermelons).

The first essential to vegetable growing is good soil. It need not necessarily be rich; a light or medium soil which is warm and quickly responds to manure and is well drained is very suitable.

The second is good fresh seed from a reliable firm. This should not be kept longer than three months after receipt before planting, for the seed will lose viability, the ensuing result being most disappointing.

Having selected and marked out the land, say twenty-five by twenty-five yards, the whole area should be dug up to a depth of six to eight inches. The beds are now marked out running east and west and not north and south as too much sun gets in under the covering this way during the mornings and afternoons.

The beds should be three feet wide with a path of eighteen inches between. This will give seventeen beds. The soil in the paths is thrown up on to the beds thus raising them from four to six inches. Manure or compost is then applied; the latter is more quickly available as plant food than the former but farm-yard manure is usually handier and easier to get and, although not so well balanced for it contains too much nitrogen, it is in itself a complete fertilizer. Also as nitrogen produces leaves, it is almost a desirable fault in that one is able to grow the essential green food such as spinach, celery, etc.

*Reprint of Leaflet No. 10 issued by Department of Agriculture, Tanganyika Territory.

Apply manure that is well rotted at the rate of six to seven pounds per square yard, distribute evenly and dig in to a depth of two to three inches. A paraffin tin holds about twenty pounds of manure, but if goat manure is to be used half the quantity will suffice. The distribution can be done by means of a rake and at the same time the levelling of the surface be achieved. Should there be any hard lumps the beds should be watered after levelling and left for twelve hours when a second raking will leave the soil moist and level ready to receive the seed.

One bed should be left entirely as a seed bed marked off into portions two yards long, and in these cabbage, beetroot, tomato, brinjal, onions, celery, kohlrabi and Brussel sprouts should be sown.

The second bed should be planted with cluster beans. These should be spaced three feet apart along either side of the bed, about four inches from the edge, and should be staggered.

The third bed planted with Okra or ladies finger (*Hibiscus esculentus*).

The fourth bed divide into equal portions and sow as follows:—

First portion: Carrots mixed with lettuce.

Second portion: Turnip.

Third portion: Radish.

Fourth portion: Spinach (New Zealand).

Fifth portion: Parsley.

When the lettuce is two to three inches high in the carrot bed it can be transplanted into another bed thus thinning the carrots at the same time: Carrots should not be transplanted but left where they have been sown.

The fifth bed.—Transfer the cabbages into this bed, setting them two feet apart, one row along either side of the bed. In between the cabbages plant the lettuce

which was grown with the carrots. A row can also be planted down the centre of the bed eighteen inches apart. Cabbage lettuce is recommended. All transplanting should be done in the evening and watered immediately afterwards.

The sixth bed plant with onions. Should small pickling onions be required one can have five rows leaving a space of six inches along either side of the bed. Plant closely two to three inches in the rows and the rows six inches apart.

The seventh bed, beetroot three rows, plant twelve inches apart.

The eighth bed, kohlrabi, same as for beetroot and lettuce.

The ninth bed, celery: Plant about twelve to fourteen inches apart in the rows, not more than three rows to the bed. To get white celery it is necessary to cover each plant and fourteen-inch pieces of old gutter piping are suitable for this purpose. This is an improvement on the old paper or cardboard funnel method as it is not damaged by white ants and can be used indefinitely.

The tenth bed, tomatoes: Plant two rows to the bed and three feet apart in the rows.

The eleventh bed, brinjal: Both long and round varieties. Two rows per bed and three feet apart in the rows.

The twelfth bed, Brussel sprouts: Three rows to the bed and eighteen inches apart in the row.

The thirteenth bed, repeat the same as fourth bed leaving out the parsley and planting spinach beet. This can also be transplanted.

The fourteenth bed the same as the first bed, and when transplanting follow out the same order.

In the rotation it is advisable to have root crops alternating with leaf crops.

The watering is a very important part and generally makes the difference between a good garden and a poor one. Irrigating by furrow is preferable to watering overhead but where this is not possible a watering can with a fine rose is necessary. Watering must be done in the mornings before 8 a.m. and again, if necessary, in the afternoons, the later the better and not earlier than 5 p.m. The water to be used in the afternoons should not be left standing in the sun all day but should be protected and kept cool under a grass covering.

Young seedlings and transplants must be protected during the heat of the day, and to do this shade must be provided. Upright forked pegs two to three inches in diameter and three feet long are planted twelve inches in the ground along either side of the bed and about ten to twelve feet apart. Along the top of the pegs (in the forks) are placed old sisal poles, and when these are in position thin laths are placed crosswise to support the covering. Ordinary grass or palm leaves may be placed lengthwise on the top of the laths. But for convenience and neatness thin half-inch reeds three feet six inches long plaited together very much like ordinary grass matting could be used. If each mat or *mtete* is about fifteen feet long five will be needed to a bed or eighty-five to cover all the beds.

The great advantage of these mats is that they can be rolled up in the afternoons before watering and rolled down again in the mornings after watering.

Watering should not be done over grass or matting as the drip is likely to wash out or disturb small seedlings and, vision being obscured, dry patches are often left where the plants or seeds consequently suffer.

The maturity table given below is approximate only, but will help as a guide. Due allowance must be made for climatic conditions, soil and cultivation.

Kind	Ready for use
Cluster beans .. .	2½ months
Beet .. .	2½ "
Brussel sprouts .. .	4 "
Brinjal .. .	3½ "
Cabbages .. .	3½ "
Carrot .. .	3½ "
Celery .. .	4 "
Cucumbers .. .	3½ "
Kohl-rabi .. .	3½ "
Lettuce .. .	2 "
Onions .. .	4-5 "
Okra .. .	3 "
Pumpkins .. .	4 "
Radish .. .	1½ "
Spinach .. .	1½ "
Tomatoes .. .	3-4 "

Parsley, spinach beet and spinach can be used as soon as the leaves are large enough to be picked without damaging the plants. The leaves must be nipped or cut off and not pulled as this disturbs the roots.

The Valuation of Manures and Fertilizers

By G. H. GETHIN JONES, M.Sc., Soil Chemist, Department of Agriculture,
Kenya Colony

In the choice of manures and fertilizers it is first necessary to decide which plant nutrient or nutrients are required for the particular soil and crop in question. The next step is to find out the cheapest source of the required nutrient, bearing in mind the relatively suitability of different forms. The cheapest source is determined by working out the relative "unit values" of the desired nutrient when delivered on the farm or when applied to the land. This matter is discussed in detail later in these notes. Suitable bulky organic manures confer extra beneficial properties. Such manures help to maintain the humus status of the soil, and their gradual breaking down by bacteriological activity gives a continuous supply of available nitrogen. The better humus content ensures a more stable soil, better tilth, better water supplies and aeration, and also makes possible the more economical use of added mineral fertilizers. Those manures which are of plant origin also supply small amounts of all the elements of nutrition which are taken up by growing plants from outside areas.

In the classification of manures and fertilizers, we read about "available" and "non-available" nutrients, and the greater manurial value is placed on the "soluble" or "available" portion. In the special case of the phosphatic manuring of the red coffee soil, this arbitrary distinction has no true meaning, as it has been shown that the water-soluble phosphatic fertilizers, such as "super" and "double super," are immediately reverted into a less "soluble" form following contact with the soil. They therefore have no greater value than ground mineral phosphates, Seychelles guano, and more especially the various grades of bone meals. In East

Africa we must discard certain arbitrary valuations of fertilizers adopted in Europe, and judge materials anew according to our own soil conditions, placing special value on bulky organic manures.

BULKY ORGANIC MANURES

A great difficulty in assessing the comparative manurial values of manures such as composts and *boma* manure lies in the fact that these bulky manures vary greatly in their composition, as shown by the total chemical analysis and again by the mechanical constitution of different samples. The different proportions of moisture and earthy matter contained in such manures greatly modify their true manurial value, and it is not possible to guarantee or to purchase these materials on the basis of any quoted standard or "average" analysis. Even when analysis of composite samples is quoted, the values are only strictly accurate for those particular lots when containing the quoted natural moisture content. Owing to different sources, composition and maturity of the usual bulky materials used and the varying earth and moisture contents present, the planter is severely handicapped when attempting to estimate the true manurial value of different lots of such materials. In the case of earthy composts, even chemical analyses are apt to be misleading, as the contained earth contributes to the quoted manurial contents. Many local composts contain about three times as much soil as they do of dry organic matter. In the analysis of such composts by acid treatment, the soil portion liberates all its contained nitrogen and much of its phosphoric oxide and potash, though the greater portion of these nutrients are unavailable for plant nutrition. The soil portion, which may

comprise the bulk of the compost dry weight does not therefore enrich the relative fertility of the land: it only adds very slightly to the depth of the surface soil.

In the estate practice of preparing bulky organic manures, for use on the estate, the chemical composition of the manurial value per ton is not of the greatest importance. The main need is to make the best possible use of all the coarse vegetable matter and organic concentrates which can be produced with the farm acreage and stock available. The presence of some earth which unavoidably finds its way into the compost, and also of somewhat excessive moisture during the rains lowers the manurial value per ton, but adds extra tonnage of material to compensate for this. However, in the case of organic manures, purchased by the ton, the water and earth ingredients displace true "compost" and the purchase is uneconomic. As earthy, and more especially wet composts, are heavier, the error of valuation is less when such materials are bought by cubic capacity, for example, by the *debi*. It is necessary for the planter to be his own judge of the real manurial value of purchased composts and *boma* manure.

The amount of contained moisture can be estimated by handling the material, but it is not possible to judge the soil content with much accuracy by this method. The soil particles, more especially if derived from dark coloured clays or silts, become coated with humified organic matter, such that the whole appears not unlike a very good sample of compost. When large consignments are involved, and there are some doubts as to its organic matter content, it is well that the planter should satisfy himself by carrying out a rough separation of the water, earth and organic matter contents of a composite sample of material. A sub-

sample of say 10 lb. of the moist material, as received, can be dried out until quite dry in the sun and weighed again, thus giving an approximation of the free moisture-content. This same air-dry material can then be ignited until fully ashed on a sheet of metal, and the residue again weighed. The loss in weight, though it includes some further moisture losses, gives an idea of the organic matter that has been removed by burning and the residue gives the soil plus the ash contents. Very rich materials and those with added mineral concentrates would contain more of the valuable true "ash" portion of the residue, but this can only be a small part of the whole in the case of suspected earthy composts. The presence of much grit and sand can be easily observed by stirring and breaking down a representative portion of the material with water. The dark fluid containing the organic matter in suspension is then decanted leaving the grit and coarse sand in the vessel. The finer soil particles do not settle rapidly enough and are therefore removed in suspension with the organic matter. This simple test can therefore only indicate that there is at least a certain proportion of heavy coarse particles present.

The amount of partly decomposed organic matter which comprises the manurial portion of *boma* manure and composts, may vary greatly in nutrient contents according to the source and treatment of the materials. Goat manure is usually about half as valuable again as a sample of cattle manure containing similar amounts of moisture and earth; again, animal manures which have been lying in the open and subjected to leaching may have only half the manurial value of properly stored materials. The organic portion of composts varies in chemical composition according to the nature of the composting materials, though in very ripe composts the manurial values tend to

be higher and fairly uniform. Thus, it is extremely difficult for the planter to estimate the comparative value of purchased bulky organic manures. In practice the price paid depends largely upon the supply and demand in the locality and on the amount of transport involved. It therefore remains for the purchaser carefully to examine the materials and to refuse or pay less than the local price for what he judges to be inferior consignments of bulky organic manures.

THE VALUATION OF CONCENTRATED FERTILIZERS

In the case of bulky organic manures of varied composition it has not been possible to suggest a practical method of determining their exact manurial value. However, imported concentrated fertilizers are uniform in composition and are sold on a basis of guaranteed analysis, hence it is possible to compare the relative manurial value of different materials. In quoting the analysis of fertilizers some sellers quote the percentage of nitrogen and then add another percentage value in terms of ammonia. This does not imply any additional amount of nitrogenous materials: it simply expresses the original nitrogen value in other terms. Again, phosphatic fertilizers may be quoted in terms of percentage phosphoric oxide (or phosphoric acid) P_2O_5 and then this is followed by a higher value in terms of tricalcium phosphate ($Ca_3(PO_4)_2$). The latter value, which is 2.184 times the former, simply expresses the same ingredient in another equivalent form, though this particular tricalcic form of phosphate may be absent from the fertilizer itself. Potassic fertilizers may be expressed in terms of purity such as 90 per cent. This value must be distinguished from other values quoting the actual percentage of potash contained in these fertilizers. The composition of fertilizers is always expressed as numbers per cent

present of nitrogen (N), phosphoric oxide (P_2O_5), or potash (K_2O). The price per ton at the nearest railway station is also known. To this price the buyer must add the transport charges on to the farm and he can deduct any discounts for cash payments or for the purchase of bulk consignments. Thus, in the case of commercial fertilizers both the guaranteed percentage nutrient contents and the cost delivered on the farm are known. Comparisons are made by determining the cost of a constant amount or a single unit of nutrient in the range of fertilizers which are on the market. The "unit" is taken to be 1 per cent of the required nutrient (N, P_2O_5 , or K_2O), and the "unit value" is the relative cost of this unit. This is done by dividing the price per ton of 2,240 lb. of the fertilizer by the percentage of the nutrient present: the "unit value" thus happens to be the cost of 2,240 lb. divided by 100, or the cost of 22.4 lb. of the active nutrient. This calculation can best be illustrated by taking a few concrete examples. Thus, if sulphate of ammonia, with a guaranteed nitrogen (N) content of 20.6 per cent, can be purchased for Sh. 245 per ton, this means that the "unit value" (1 per cent) of the nitrogen nutrient amounts

$$\text{Sh. } 245 \\ \text{to } \frac{\text{Sh. } 245}{20.6} = \text{Sh. } 11.90.$$

THE VALUATION OF PHOSPHATIC FERTILIZERS

In the valuation of phosphatic fertilizers it is customary to divide these into "soluble" and "insoluble" forms and again the same fertilizer may be valued according to the proportions of these different forms which it contains. In European practice the insoluble portion is calculated as having only half the manurial value of the soluble portion. In the case of the acid, red lateritic soils bearing a permanent crop like coffee it is held that this arbitrary reduction in the relative

manurial value of the water and citric acid insoluble portion of the phosphoric oxide is not justified. In the particular case of such soils it has been shown that the soluble portion of a phosphate fertilizer immediately reacts with some of the active iron and aluminium compounds in the soil and becomes "fixed", thus losing its supposed enhanced value due to its supposed greater solubility or availability to the growing plant. It must be stressed that these remarks are based on the special chemical constitution of the acid red lateritic soils. In the case of most other soil types under cultivation, the soluble forms of phosphates would be expected to be more available, especially in the case of annual crops. We learn that with the red coffee soils some special arbitrary method of valuing phosphatic fertilizers has to be decided upon. Mineral phosphates and bone meals can be better mechanically distributed throughout the surface soil; whereas the soluble forms of phosphate react immediately with the soil and tend to accumulate in a very limited depth of soil. Ultimately, the reserves of both forms react to form the same fixed phosphate compounds. It is, therefore, suggested that in the valuation of phosphatic fertilizers intended for the typical red lateritic coffee soils they be valued according to their total phosphoric oxide content. Thus, there would be no greater unit valuation for that portion which is "soluble" before application to these soils but later becomes reverted to a much more insoluble form.

All potassic fertilizers are soluble and behave in a similar manner when applied to the soil. Their comparative unit value can be determined directly by dividing the price per ton by the percentage of potash (K_2O) which they contain.

THE VALUATION OF MIXED FERTILIZERS

So far we have been dealing with straight or single nutrient fertilizers and

comparisons have only been possible with fertilizers of the same class. Once we know the prevailing unit values of single nutrients, this information can be used for judging the cheapest source of mixed or compound fertilizers. The summation of the values of the different single nutrients suggests what should be paid for mixed fertilizers. The calculation is done by finding out what would be the cost of obtaining the quoted percentages of the different contained nutrients if they were bought in the form of single fertilizers. As many compound fertilizers can supply the nutrient in a more concentrated form than a mixture of single fertilizer, there is need to assess the cost of the material when delivered on to the farm, thus allowing for the relatively cheaper transport charges for the nutrients in the concentrated fertilizer. An allowance must also be made for the even composition and the good mechanical condition of factory-made mixtures.

An illustration of the method of calculating the manurial value of a compound fertilizer will illustrate the method of valuation. Let us suppose that sulphate of ammonia containing 20.6 per cent N. can be landed on the farm at Sh. 247/20 per ton; similarly that a suitable mineral phosphate containing 30 per cent P_2O_5 would cost Sh. 120 and that muriate of potash (which is usually contained in mixtures) containing 60 per cent of K_2O would cost Sh. 270. From these assumed values we get the following unit values for N., P_2O_5 and K_2O respectively:

Sh. 247/20	
Unit value of nitrogen	—
20.6	= Sh. 12
Sh. 120	
Unit value of phosphoric oxide	—
30.0	= Sh. 4
Sh. 270	
Unit value of potash	—
60	= Sh. 4/50

Now let us assume that we have the option of buying a certain mixed fertilizer

which has a guaranteed analysis of 8 per cent N., 16 per cent P₂O₅ and 8 per cent K₂O, and that this can be delivered on to the farm at Sh. 210 per ton. Having obtained the prevailing unit values from a study of the cost of straight fertilizers on the market, we can calculate how much the quoted mixed fertilizer should cost on the farm. Thus:

	Sh.
8 per cent nitrogen at Sh. 12 per unit	96
16 per cent phosphoric oxide at Sh. 4 per unit	64
8 per cent potash at Sh. 4/50 per unit	36
Add allowance for thorough mixing and for suitable condition of fertilizer—say Sh. 10	10
	<hr/>
	Sh. 206

It has been shown that this particular mixed fertilizer is worth about Sh. 206 per ton. The calculated value is then compared with the actual cost of the material delivered on to the farm, thus giving the farmer a fair guidance as to the economy of the purchase.

Other aspects relating to the choice of fertilizers have to be considered. The variation in the composition of mixed fertilizers and hence the choice, is necessarily limited. The farmer has to consider whether he can select a mixture that suits his special requirements and that it does not contain some nutrient which he normally would not purchase. In the above example it will be noted that Sh. 36 per ton is paid for the potash nutrient which he may not require or which he may be able to buy much cheaper in the form of wood ashes. Again in a mixed fertilizer containing nitrogen, the farmer cannot adopt the most suitable time and manner of applying the separate ingredients of the fertilizer. It is better that the phosphate portion be applied immediately before a deep cultivation before the rains, whereas the soluble nitrogen is best applied later as a productive top-dressing according to the condition of the trees.

Let us again examine the value of a very concentrated nitrogenous and phosphatic compound fertilizer based on ammonium phosphate. Such a fertilizer, having a 1: 2: 0 ratio of N., P₂O₅, and K₂O, has a guaranteed analysis of 15.6 per cent nitrogen and 31.9 per cent phosphoric oxide (no potash) sells at Sh. 323 per ton and can be delivered on to the estate for, say Sh. 330 per ton. Thus:

	Sh. cts.
15.6 per cent nitrogen at Sh. 12 per unit	187 20
31.9 per cent phosphoric oxide at Sh. 4 per unit	127 60
Allowance for mixing and special condition of fertilizer—say Sh. 15	15 00
Calculated manurial value per ton	<hr/> 329 80

The above summation shows that it can be purchased at about its manurial value even when allowing the low unit value of Sh. 4 for phosphoric oxide as in mineral phosphates and bone meals. One ton of this very concentrated fertilizer contains as much nutrients as would be contained in about 2½ tons of mixed fertilizer, hence the saving in ocean and railway freights, and more especially when long transportation by road is involved.

However, as such fertilizers contain nitrogen and phosphate, there arises a difficulty about the most suitable time and method of application to coffee lands. It is best that such fertilizers be applied to suit the nitrogen portion and that the contained phosphate be considered as adding to the phosphates reserves of the soil.

It is suggested that the planter should maintain a record of all the manures and fertilizers given to different blocks of coffee so that he can estimate what reserves of phosphate and potash have been given to the land. Further amounts of nutrients contained in bulky organic manures can also be included, though it is difficult to estimate these with any degree of accuracy owing to great variations

in the chemical composition of such materials. They may contain .4 per cent to 1.2 per cent of nitrogen, .3 per cent to .8 per cent phosphoric oxide, and .5 per cent to 1.5 per cent of potash. Thus a 10,000 lb. application would supply 40 to 120 lb. N., 30 to 80 lb. P₂O₅, and 50 to 150 lb. K₂O.

These summations cannot be done by taking the weights of fertilizer applied; there is need to total up the values of the variable essential nutrients in terms of phosphoric oxide and potash respectively. It is not possible to sum up the total of added organic matter and nitrogen. It is the further breaking down of the organic matter that yields the available nutrients, more especially nitrates, and over a number of years the organic matter or humus level of the soil approaches an equi-

librium with soil climate and cultivation methods. It is also considered wise to have long range manurial programmes and to arrange these in good time.

It might be well to repeat that the special observations and recommendations with regard to phosphatic manures and the special valuation of such fertilizers applies only to the case of the red lateritic soils. It is probable that this would also apply to similarly derived yellowish, orange, and buff-coloured soils. With other soil types and more especially for annual crops, it is likely that the more soluble forms of phosphates would be the more suitable and therefore should be allotted relatively higher unit values than of Sh. 4 based on insoluble phosphatic fertilizers which are considered suitable for coffee growing on red lateritic soils.

Correspondence

THE EUCALYPTUS WEEVIL

Sir,

With reference to my recent article¹ on the presence of *Gonipterus scutellatus* on eucalyptus in Nyasaland, it may be of interest to record that I have now found (yesterday to be exact) this insect to be present at Lourenço Marques in Portuguese East Africa. I believe this is the first record of the insect from this territory, and I think supports my contention that it is far more widely distributed than has been realized.

As stated in my article, the presence of this insect in Portuguese territory had not been reported as far as I was aware, and therefore a note on the present discovery, in a forthcoming issue of the *Journal* might be of interest.

COLIN SMEE,
Entomologist,
Nyasaland Protectorate.

S.S. Taivea,
Durban.
22nd March, 1938.

¹E. Afr. Agric. J. III, pp. 173-175.

Factors Affecting the Composition of Milk and the Quality of Butterfat

*By M. H. FRENCH, M.A., Ph.D., Chemist, Veterinary Department,
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Milk is the food elaborated by the mother for the nourishment of her young until such time as they are able to digest and assimilate the normal food of their species. Milk is an emulsion of fat globules in a colloidal solution of proteins, lactose and mineral matter. At birth, mammalian young differ considerably because the extent of intra-uterine development varies with each species. Since milk is nature's food designed to meet the requirements of these varyingly developed offspring, the composition of the mother's milk must differ between species. These variations can affect the levels of any or all of its constituents.

The word "milk" is now almost synonymous with "cow's milk", because this species has been selected and bred by man for increasingly big milk yields in order that cow's milk could play a larger and larger role in human dietetics. The study of factors affecting milk and butterfat compositions has therefore been made very largely on cow's milk although these same changes would be paralleled in the differently composed milks of other species. The following remarks are restricted to cow's milk and deal only with the variations in the fat and non-fatty solids.

THE INFLUENCE OF BREED

There is a marked difference between the breeds of cows in the fat content of their milks, e.g. the difference between Jersey and Friesian milk is well known. When such breeds as the Zebu and the Friesian (with their widely differing fat contents) are inter-bred the amount of fat in the milk of the offspring varies directly with the amount of Zebu blood

in these grade animals. Not only is there a difference in the fat content between breeds but the size of the fat globule varies from the large globules in Guernsey milk to the small ones in Ayrshire or Friesian milks. The larger the globule the easier it is to separate the cream and to make butter, whereas milks with small globules are better suited for cheese production.

The colour of butterfat varies enormously between the different breeds, and milks with a highly coloured fat, such as that from the Channel Island breeds, are often mixed with the milks from other breeds (Ayrshire and Friesian), which have pale coloured fats, to improve the attractiveness of the cream layer. Because the colour of butterfat is derived very largely from the carotene of the food, the colour varies directly with the amount of green foods in the diet. Since carotene is a precursor of vitamin A, high fat colour is popularly associated with high vitamin A activity of the milk. This is not necessarily correct because vitamin A itself is colourless, and one can have pale milks possessing a greater total vitamin A activity than highly coloured Jersey milks. Both the vitamin A and the carotene contents are dependent on the supply eaten in the food and are liable to marked seasonal fluctuations. However, for each of these substances there is a "ceiling" value for each breed, above which the level cannot be raised.

The chemical characteristics of pure butterfat do not vary significantly between breeds (Zebu butterfat is not distinguishable by the ordinary analytical procedures from Ayrshire butterfat).

INDIVIDUAL IDIOSYNCRASIES

Although the composition of milk from individual cows tends to approximate to the mean for the breed, certain animals always give milk differing significantly from this average in content of both fat and non-fatty solids. Individuals giving milk below the breed average should not be used for breeding-up the herd.

VARIATIONS DURING MILKING

First drawn milk is poorer in fat than last drawn milk (strippings) but no such variation occurs in the content of solids, non-fatty. The cause of this is thought to be the holding up of the fat globules in the finer ducts by capillary forces, whilst the more fluid portions pass on into the cisterns and are removed as first drawn milk. Erection of the udder during, or even before, milking increases the internal pressure of the udder and dislodges the fat globules from the ducts. Certain milkers always produce a greater erection than others and so obtain a more complete removal of the fat globules than other milkers.

The size of the fat globule in the first drawn milk is smaller than in the stripplings. Butter made from first drawn milk is harder than that made from stripplings owing to its lower contents of oleic and soluble volatile acids.

There is no significant variation in the non-fatty solids content of the milks from the different quarters of the udder. The milk from the fore quarters is usually richer in fat than that from the hind quarters, but the greater yield of the hind quarters allows them to yield a greater total weight of fat than the fore quarters.

VARIATIONS DUE TO LENGTH OF INTERVAL BETWEEN MILKINGS

Morning milk, which is usually drawn after a longer interval between milkings

than evening milk, is poorer in fat content. With equal intervals between milkings this difference in fat content disappears. The difference is caused by the greater filling of the udder during the longer interval, producing a higher internal pressure. This increased pressure not only reduces the activity of the secreting cells by flattening them, but also retards the passage of the fat globules from the finer ducts to the cisterns.

THE EFFECT OF THE STAGE OF LACTATION

The first secretion (colostrum) removed from the udder after parturition differs markedly from normal milk, particularly in its much higher globulin and albumin contents. In from three to five days after parturition the composition of the udder secretion has altered to that of normal milk.

During the lactation period the fat percentage falls to the point when maximum yield is obtained and, after a stationary period, the fat content again increases during the last two months when the yield is falling. The non-fatty solids content shows similar variations.

The size of the fat globules decreases steadily throughout the lactation period; there is also a marked tendency for the butterfat to become softer in the later stages of the lactation owing to an increase in the oleic acid content. With advancing lactation there is a lowering of the volatile acids in the butterfat.

THE EFFECT OF AGE

With each succeeding lactation there is usually an increase in yield up to about the seventh lactation. Normally the fat content is not significantly altered because with each pregnancy a further increase takes place in the number of secreting cells in the udder. On the other hand, the content of non-fatty solids tends

to drop with each succeeding lactation and cows which have been in the herd a long time are thus liable to give milk which is below the legal minimum in its non-fatty solids content.

THE EFFECT OF YIELD

Increased yields between individuals of the same breed, and even in the same animal, are accompanied by a decreased fat percentage, though the total yield of butterfat is increased. Breed differences can be partly, but not completely, explained by differences in yields.

THE EFFECT OF SEASON AND CLIMATE

In hot countries milk is usually richer in both fat and non-fatty solids than the milk of temperate regions. This is often a result of the lowered yields encountered in the tropics.

In any given climate, seasonal changes affect the composition of milk in that a higher temperature, especially if it is associated with droughty conditions, lowers the content of fat and non-fatty solids.

EXERCISE AND NERVOUS INFLUENCES

Moderate exercise tends to reduce milk yields but to increase the percentage of fat in the milk. Climbing hills and other more strenuous exercise reduces both the yield and the fat content. Maltreatment, fright, shock and temper reduce the quantity of milk.

THE EFFECT OF INFLAMMATORY UDDER TROUBLES

Many cases of mastitis and other inflammatory conditions of the udder have been found to be associated with milk of lowered fat content and deficient in non-fatty solids. This condition is attributed to a dilution of the normal milk in the udder by a fluid of the nature of a tissue exudate or a plasma filtrate, similar in composition to lymph serum

of pathological origin. The dilution continues for some time after the obvious clinical symptoms have disappeared.

THE EFFECT OF WATER SHORTAGE

Lack of drinking water reduces considerably the yield of milk, which in its turn causes a somewhat higher fat content. The content of non-fatty solids is unaltered.

THE INFLUENCE OF FOOD

Many workers have produced evidence of the intimate quantitative and qualitative connexions between the food fed to cows and the milk produced from this food. It is now well known that the change from winter stall-feeding conditions to summer pastures causes increased colour and softness in butter, whilst the reverse occurs when cows are put back on to winter feeding conditions. Many farmers believe that the feeding of oil cakes and other foods rich in fat causes an increase in the fat content of the milk; this effect is however merely transitory and the quality of the milk returns to normal in a week or two. It occasionally happens that a herd gives milk deficient in its content of non-fatty solids, and though the results obtained in England and South Africa indicate that the level of this milk fraction cannot be influenced by the feeding of minerals, vitamins or green foods the question should be considered as still open. Lack of food causes a reduction in the yield rather than a lowering of quality.

The consistency of butter is affected considerably by the nature of the food fed. Young green grass and clover produce a soft butter, but when converted into hay or silage, grass loses this property. Coarse roughages, hay and straw, make a hard butter and the same can be said of roots and cabbages. Barley produces a hard butter, whilst peas and

beans make the butter brittle as well as hard. The effect of concentrate foods on the butter quality depends on the intake and nature of the food oil. High consumption of oil of low iodine value leads to the formation of a hard butter, but a high consumption of an unsaturated oil of high iodine number produces a soft butter. Thus sesame, linseed, rape and sunflower cakes or seeds and rice by-products produce a soft butter, whilst hard butter results from feeding leguminous seeds, coconut and palm kernel cakes. Butter of medium consistency is formed from groundnut, soya bean, and cottonseed cakes. Cottonseed itself can be fed in large amounts to cows without interfering with the quality of the milk, though churning will take slightly longer, and the butter will be pale and hard. Excessive feeding of almost any food will give unfavourable results and mixed diets are always the best. Excessive amounts of fresh young clover or lucerne, for instance, may result in the development of a fishy flavour in the butter. Large quantities of locally extracted oil-mill residues mean the intake of excessive amounts of their oils, and the appearance in the butterfat of those chromogenic substances which give rise to the specific tests for that particular oil, e.g. after cows have eaten local sesame cake their butterfat gave the characteristic Baudouin's test for sesame oil.

STORAGE

There is a popular belief in certain countries that "rich milk does not keep so well". In East Africa nearly all milk is rich in fat, but it has been found that if milks of high and low fat content are drawn under equally clean conditions there is no difference in keeping qualities.

Long storage of butter, even at low temperatures, results in a loss of colour

and the development of tallowy flavours, particularly in the surface layers. This change is due to autoxidation of the fat, with the production of substances which give the butter a rancid taste and smell. It has been found that this change is accelerated by a moist atmosphere and by sunlight. Also, if the butter becomes contaminated with certain metals of the iron group this autoxidation is still further accelerated. For the best results, storage of butter and ghee should be done in containers which exclude moisture, sunlight, and air.

SUMMARY

The main points to be learnt from the above summary are:—

(i) Provided a satisfactory balanced ration is fed, milk and butterfat yields cannot be permanently increased by extra or different feeding.

(ii) The feeding of ground-nut cake and cottonseed during the wet season will help to counteract the normal tendency to give soft butter, whilst the feeding of sesame cake in the dry season will help to prevent the butter becoming hard.

(iii) In the hot areas of East Africa butter of hard consistency is required and so, when highland butter is to be sold to these lower areas, efforts should be made to harden the butter by feeding suitable foods.

(iv) The vitamin content of milk will vary greatly between the wet and dry seasons.

(v) Grading up Zebu cows to a dairy breed must be done cautiously, otherwise the increased yields of the higher grade animals may be offset by their lower fat contents and creamery cheques will suffer.

Farm Fencing—Part V

By L. A. ELMER, Assistant Agricultural Officer, Department of Agriculture, Kenya Colony.

GATES AND STILES

A gate should be made to rest its weight when closed. A small block of wood fastened to the gate post will take the weight, if the appropriate gate rail is left a few inches longer. Alternatively, the fastening apparatus should be such that the same object is achieved.

For ox transport the gateways should be 16 feet wide. This is too wide for a single gate and two 8 feet gates are used, or a 15 feet gate supported by a cable. As double gates are very liable to sag it is most important that the rails fastening gate-posts to the adjacent strainers should be stout and well bolted. Ox-drawn transport requires a straight run at a gate, at least 40 yards for a full team.

To save opening and shutting a gate unnecessarily a stile is often made by the side. Where this is needed it is useful to leave a gap of about 4 feet between gate and strainer posts and the rails can easily be climbed by pedestrians. A stile placed where a foot path crosses the fence preserves it from damage. The hand post, or rail to hold on to, should not be forgotten, otherwise people crossing will bear down on the top wire and slacken it.

In America the need for haste, or the public nuisance who cannot be bothered to close gates, has resulted in the development of grid openings in fences. Cars can pass without stopping. A grid consists of a frame about 10 feet by 10, made of 2 in. by 4 in. poles placed on edge, about 3 to 4 inches apart, on two or three stout beams. It is placed flat on the ground on the opening in the fence over a pit nearly as big as the grid and

about 2 feet deep. Animals are frightened of stepping on it. It seems dangerous and might cause damage to frightened stock or game and it does not do away with the need for proper gateways through which stock can pass safely.

Where gates are in roads which are used a lot, the best method of ensuring that they are shut is to put up a double-sided notice board: "PLEASE SHUT THE GATE" for, strange as it is, there are many people who do not realize the purpose of a gate and seem to imagine it is put up to annoy travellers. The self-shutting gate usually enrages the solitary motorist, who ends by wedging it open and leaving it open.

The following illustrations will be a guide to the man who has never made a gate.

Fig. 1.—The gate illustrated is copied from a sketch sent by a settler. It is not drawn to scale. The gate is 15 feet wide. The timbers are of 4 in. by 2 in. musharagi (Olive, *Olea Hochstetteri*) bolted with $\frac{1}{2}$ in. bolts. The cable is of $\frac{1}{2}$ in. round iron threaded at the lower end and passed through a ring bolt in the bottom of the gate so that slack can be taken up by tightening a nut. When closed the top rail rests on a block of wood bolted to the gate post.

Fig. 2.—This design is common in England. The top and bottom rails are usually 1 in. to $1\frac{1}{2}$ in. thicker than the three inside ones; this allows the diagonal to fit flush at the corners and support the weight better. This design can be followed, using seasoned wattle poles, which, if creosoted several times and given an annual coat, will last many years.

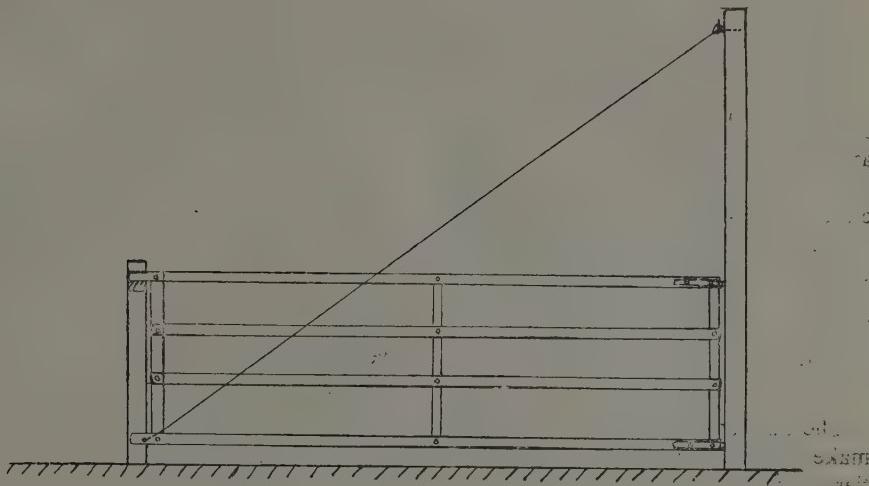


FIG. 1

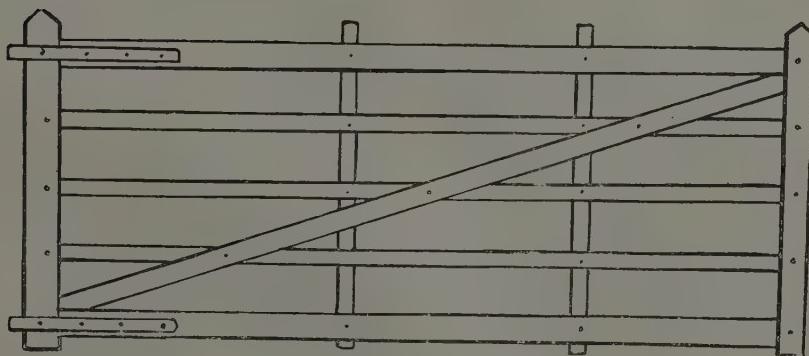


FIG. 2

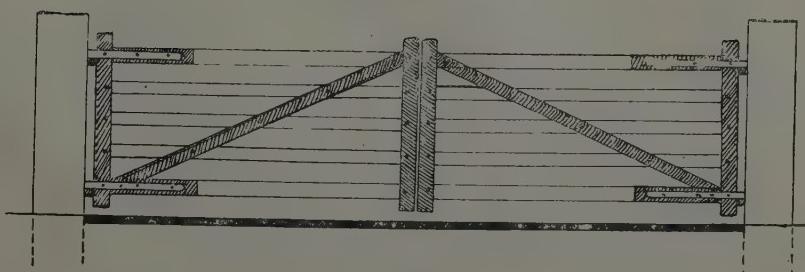


FIG. 3

Fig. 3.—Double gates giving a 16 feet opening. The gates are made of 3 in. by 1 in. battens bolted together with 3½ in. by $\frac{3}{8}$ in. bolts. In the illustration the shaded parts represent double battens and the unshaded parts single battens. The double battens are placed one on either side of the single rails and bolted. If the wood shrinks, a turn can be given to the nuts. Washers should be used. A gate of this description will last a long time if well creosoted and given an annual coat in the dry season.

METHODS OF TREATING TIMBER

The time of cutting does not appear to make any difference to its lasting qualities or to the amount of sap in wood. It merely dries more quickly in the dry season. Fast grown timber with a lot of sap wood can be used provided it does not "pop" or split excessively before or after treatment. Timber should not be dried too quickly: nothing definite can be laid down, but a good general rule is to dry fast grown timber slowly. If the timber is likely to crack excessively it should be cut at the beginning of the rainy season, drying will thus be slower and there will be fewer and smaller cracks. After felling, the bark should be removed and great care taken to get it all off at butt ends which will go into the ground.

A stack should be on brick, stone or ant-proof piles 12 inches high and built with four or five logs laid one way and seven or eight the other, alternately all the way up. There must be a space between the poles. For quicker seasoning reduce the alternate layers to three and five. A good circulation of air is essential. The stacks should be under a roof if possible and be left for at least six months, but watched for white ants.

Creosote is very effective for general purposes. Ordinary tar or mineral oils are

not recommended as they are less poisonous to fungi and their penetration is less than creosote.

Where the cost of creosote is high it is an economy to dilute it with petroleum oil, e.g. old car or tractor oil, but the best for this purpose is a light fuel oil or crude petroleum such as is used in Diesel engines. Mix two parts creosote to one of oil. Under no circumstances should timber be treated with oily preservatives if unseasoned or recently wetted by rain.

A patch of dry rot in a cedar post should be cut out before treatment; the preservative will kill the fungus but the rotten wood will soak up a lot if left and, as it has no strength, there is no object in leaving it.

The life of well treated timber should be at least twenty to twenty-five years. Use creosote for wet districts, and water solutions for dry places. Treat timber in the dry season.

Creosote and Oil Mixture—Open Tank Process

Use forty-gallon oil drums. Stand one on bricks to take a small fire underneath. Two or three drums will take the cold liquid and others will be used for draining the posts. Place a charge of posts, butts down, in the boiling drum and fill up with the mixture to about 9 inches above the future ground level of the posts, i.e. if the fencing posts are to be planted 24 inches deep fill up to 33 inches.

Light a small fire and keep the liquid at about 200° F. for four hours, adding more mixture to maintain the level. It must not be boiled or the whole affair may catch fire. Use a thermometer to test the temperature. Too great a heat will cause excessive loss through evaporation. The heat expels some of the air in the cells of the wood. After four hours re-

move the posts and put them into the drum of cold mixture. During cooling the remaining air in the wood shrinks and the preservative is sucked in. The absorption is more rapid in the earlier stages of cooling. Leave all night in the cooling solution and then remove to the draining drums or to a sloping rack where the butts can drain on to the sheets of galvanized iron arranged with a pan to catch the surplus.

If the charge of posts be put into hot liquid the level should not be higher than 18 inches before the posts are inserted, otherwise it may flow over into the fire.

If the posts tend to float up, make a false bottom out of the top of the drum and nail or rivet battens across it and put nails or screws through to project $\frac{3}{4}$ inch and wedge it to the bottom of the drum. The posts can then be stuck on to the points and held down. Or if the posts are all the same length a piece of wire netting can be wired over each charge to holes made in the top of the drum. An iron trough will be needed for treating long perishable timbers over their whole length.

A 6-inch diameter post takes in about $2\frac{2}{3}$ lb. of mixture on a length of 33 inches, i.e. about 28 gallons per 100 posts.

Water Soluble Preservatives.

Unseasoned timber can be treated fairly satisfactorily with water solution but the treatment will be much better if the posts are thoroughly dry.

Sodium Fluoride.—A white powder. Dissolve 4 lb. in 10 gallons water at normal temperature. Poisonous to fungi but not to termites.

Zinc Chloride.—Sold in solid form or a heavy concentrated solution containing 50 per cent of the salt. Very soluble. Poisonous to fungi but not to termites.

4 lb. to 10 gallons of water, 8 lb. of the liquid to 10 gallons.

White Arsenic.—A white powder, 2 lb. to 10 gallons of water. It must be boiled to dissolve it. It is only useful against termites.

Wolman Salts.—These are very good. They proof wood against both fungi and termites. 1 lb. to 5 gallons.

Australian Treatment

Recipe for 40 gallons water solution.— Fill a 45-gallon drum up to 2 ft. 2 in. with cold water, add $14\frac{1}{2}$ lb. sodium fluoride or solid zinc chloride or its equivalent of concentrated solution and $8\frac{1}{2}$ lb. of white arsenic. Boil for thirty minutes, stir, add water to maintain the level. The treatment is similar to the creosote mixture but the water solution can be boiled for four hours. Water must be added to maintain the level. Remove the posts to a drum of cold solution and add more solution as the level drops. Leave all night. A 6-inch post takes in about half a gallon. Drum should be marked outside at the appropriate levels.

Treatment recommended by the Forest Department of Kenya

Stand a 40-gallon drum on end so that a fire can be made underneath. Fill the drum about two-thirds full of water. Heat the water by a fire under the drum: when it is hot add the preservative salts and stir well until all is dissolved.

Stand as many fence posts in the drum as it will hold (generally about five to twelve, depending on size). Keep the solution very hot (but not boiling) for five hours then rake out the fire and leave the posts to stand in the cooling solution for nineteen hours. At the end of this time take them out, add water and preservative salts (in the right proportions) to bring the solution in the

drum up to the original level, relight the fire, put in a fresh charge of posts and continue as before.

If a lot of posts are to be done it pays to have several drums going at once. One boy can easily look after three. Wolman Salts "Tanalith" is a good preservative.

A green gum (Eucalyptus) post absorbs rather less than half a gallon of solution during treatment, a dry post rather more than half a gallon. Total cost of treatment, including boy's wages, firewood and cost of preservative is Cts. 20 to Cts. 25 per post.

Woods of low durability should have the *tops* dipped in the hot solution or mixture for fifteen minutes or be brushed several times, particularly wire and mortice holes.

Other Treatment

Cold Steeping, water solutions only.—If cold steeping is done in a tank the timbers should be left in for some weeks. This is not recommended, as it is slow, but it is mentioned in case a farmer has an idle cattle dip on or near his farm.

Dipping.—Place seasoned posts in the hot creosote mixture for five to fifteen minutes. It is not so efficacious as the first process but lengthens the life of posts.

Dipping the butts in the hot water solution is not recommended.

Brushing.—This is really only of use with oily preservatives. Brush on hot at a temperature of 200° F. It must be done carefully and all cracks filled with liquid. Several coats are necessary. It is not recommended for permanent fence posts as it only lengthens the life of timber by a few years.

Care of Treated Timber

If it is not intended for immediate use after drying, timber should be open

stacked as described above, but an interval of 3 inches between posts will be sufficient.

Great care should be taken when using water-soluble preservatives to keep them away from stock; some are very poisonous. For less than the cost of one cow a fence with a gate can be made round the ground used for treating timber. Tins of poison should be locked up daily when the work is over.

HEDGES

Hedges can give a great deal of protection to animals and gardens from wind and driving rain, but will make small enclosures damp and unhealthy if allowed to grow very tall. They occupy rather a lot of space and compete with growing crops planted close to them but these are not very strong objections where land is cheap.

Planted across slopes they help to check erosion and, unlike a dead fence, a hedge is always increasing the humic content of the soil near it. The soil from under an old hedge is excellent for potting purposes. Where conditions are favourable a hedge is often cheaper than any other kind of fence but its vulnerability to fire should be remembered.

Hedges need a fair amount of attention, particularly during growing weather when labour cannot be spared easily. Neglected hedges can be a source of weed seed, couch grass and insect pests. They are apt to acquire gaps and die out in patches. Where privacy is desired in a garden a hedge is excellent and also where a very visible fence is wanted. Poisonous plants must be avoided where animals are likely to have access to them.

A hedge may take five or six years to become an effective barrier for stock but against this must be set the long life of one planted in a suitable environment.

The Forest Department recommends the following hedge plants:—

Kei apple, *Aberia caffra*.

Monterey cypress, *Cupressus macrocarpa*.

Portuguese cypress, *Cupressus lusitanica*.

Arizona cypress, *Cupressus arizonica*.

Himalayan hawthorn, *Crataegus crenulata*.

Australian myrtle, *Leptospermum laevigatum*.

Japanese privet, *Ligustrum ovalifolium*.

Brown olive, *Olea chrysophylla*.

Pencil cedar, *Juniperus procera*.

Duranta Plumieri.

The above ten plants all need clipping to make dense hedges; the two following are scrambling impenetrable plants which take up more room and only require slashing from time to time:—

Mauritius thorn, *Caesalpinia sepiaria*.

Sodom apple, *Solanum samphylacanthum*.

This Sodom apple is not the common weed so often seen, but a bushy type which grows less rankly than Mauritius thorn.

When considering hedge plants, all available information should be sought to avoid making some mistake which may cause trouble in the future. For instance, hibiscus is a host of mealy bug and should not be planted near coffee, cypress will burn freely in the dry season and in certain localities *Cupressus macrocarpa* dies out in patches. Kei apple can be scorched and will grow up again, Mauritius thorn will even stand a fire through it and shoot again from the root stumps if they are not burnt too low.

There is still a lot to be learnt about hedges in East Africa. The best all-round

hedge plant is Kei apple, it stands drought well when established, is long lived and can be trained to form an effective barrier to stock. Where appearance counts it must be clipped regularly in the growing season before the new thorns on the shoots become hard. Good hedges of Kei apple have been established by planting cuttings about $\frac{1}{2}$ inch thick, but it is safer to raise plants from seed.

Planting

The preparation of land for hedges should be carefully done and the soil loosened to a depth of 12 inches. For long hedges a subsoiler may be run along the line, followed by two or three ploughings towards the centre line. In districts where there is a luxuriant growth of bush grass, and fires are to be feared, the width of the cultivation should be at least seven yards. It is essential to clear the line of couch grass and other bad weeds; if this is done some months in advance any piece of couch left will show up before planting.

The line should be examined and ant hills cut down, where there are bad patches of soil they should be manured or, if in the base of an ant hill, a trench should be dug and filled with good soil.

On soils liable to erode quickly it is dangerous to cultivate lines down hillsides without taking the precaution of cutting side drains to carry off surplus water. Arrangements must be made to prevent storm water from above flowing through a hedge; culverts may be necessary.

When seed is planted a good tilth is needed. Some seed should also be planted in boxes six weeks before to supply misses in the line. The beginning of the long rains is the safest time for planting. A young hedge must be weeded carefully and couch grass kept out. Weeds

will not harm an established hedge. Good old Kei apple hedges can be seen with grass growing right up to them.

Hedges are best trimmed to grow wider at the bottom to encourage a thick growth low down. Clipping should be done often enough to avoid having to cut back a lot of thick woody growth. Young bush growth can be slashed off quickly with a light bush-knife ground to a fine edge, but if this practice is continued the shape of the hedge gets bad and efforts should be made once a year at least to clip it properly to shape.

DRY STONE DYKES OR WALLS

A dry stone wall is a cheap and durable fence where plenty of fairly flat stones are available. No foundations need be dug; all that is necessary is to smooth the base line and consolidate it with a garden roller. It need not be levelled. A wall 4 feet high should have a base of about 24 inches tapering to 10 or 12

inches at the top. In building, two wooden frames of the dimensions of the wall are used about 20 feet apart, with guide strings. The foundation stones should be large and tamped well into position. In every course bonding stones reaching from one side of the wall to the other are needed every five or six feet and joints in one course must be covered on the next. A proportion of small stones can be used to fill interstices. When the wall has been built to a height of about 3 feet 3 inches, large flat stones of the correct width are set, on which the top and final row of heavy cope-stones are placed. After a little practice a man with two assistants should be able to build 15 to 20 feet of wall daily.

For carting stone over rough country a sled made from a forked branch on which poles are nailed is the best vehicle. It is easily loaded and unloaded. Loads of stone should be dumped each side of the building line. The only tools needed



are a sledge hammer, stone-dressing hammers and a shovel for collecting fragments.

LIVING WATTLE FENCES

In the Kenya Agricultural Department's Bulletin No. 6 of 1934", "An Economic Study of Dairy Farming in Kenya", by V. Liversage, there is an interesting suggestion on page 14, of a narrow plantation of wattle with wattle poles nailed to the growing trees to form a fence. As he points out, "wattle makes a useful wind break and shelter for cows in exposed districts". This must surely be the cheapest type of semi-permanent fence in existence.

It is suggested that farmers, particularly those who are short of fuel, should plant belts of wattle from six to thirty yards wide surrounding areas for paddocks and, when the outside rows are strong enough to carry rails, the inside trees can be thinned out and used for the purpose. If the farm is small a single line of trees would suffice and the rails could be grown in a compact plantation where they would tend to grow straighter

and taller than in a narrow belt. Rails could be expected to last three to six years without treatment, according to the humidity of the district. A succession of small plantations put in every three to four years would maintain the supply of rails.

When planting, it is very necessary to allow each tree sufficient space to develop. One acre of wattle should provide at least 4,000 yards of rails.

Single lines of trees can also be strung with wire.

Eucalyptus trees are not recommended for planting around paddocks; they are greedy of moisture and their style of growth does not permit of such suitable shade and shelter as wattle. They often get top-heavy and crash in a storm. The life of a wattle tree may be taken as from fifteen to twenty years, the shorter in a warm district. If fairly wide belts are planted the surviving trees inside the plantations can be cut out and used four or five years before the fence trees die; new trees can then be raised ready to carry on the fencing lines.

CORRIGENDA

FARM FENCING, PART II:—

E. Afr. Agric. J. III, No. 3 (Nov. 1937),
p. 216—

line 4, for "2 in." read 2 ft.

line 7, for "4 in." read 4 ft.

A Fencing Corner

Mr. S. J. Bosch, of Nairobi, sends the accompanying drawing and writes as follows:—

"I am enclosing diagram for the construction of a very good corner. I have used it for making corners for the last thirty years and have found it most satisfactory and economical.

I am sure many farmers and others will be glad to know how to make it. I shall be glad to demonstrate it to anyone interested if they care to call at Mathari Hospital where many such corners can be seen in the bomas."

